SIMPLIFIED DESIGN OF CONCRETE FLOOR SYSTEMS

With Design Tables

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PORTLAND CEMENT ASSOCIATION

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To those who design
ECONOMIC FLOORS:

THE availability and economy of materials used in reinforced concrete make this form of construction ideal for floors for all uses. The very nature of concrete permits a flexibility in the size and arrangement of floor members. It materially lowers insurance rates.

Concrete floors are rigid and have great load carrying capacity when correctly designed. With the proper finish these floors are easily kept clean, and wear is negligible. Their long, useful life with minimum maintenance cost produces an ideal economic combination.

This booklet enumerates and discusses various concrete floor systems, shows their respective advantages and relative economies, and illustrates the method of design by typical examples. Different floor constructions suitable for a set of specific requirements are analyzed to illustrate the procedure in determining the most economical type.

Safe load tables of numerous types of slabs and beams are given to assist the designer by simplifying the calculations involved. These tables are based on requirements in the building code of the American Concrete Institute, as this code has come into quite general use. Differences between this code and local building codes, if any, must necessarily be taken into account by the designer.

Portland Cement Association

Simplified Design
of
Concrete Floor Systems

SECTION I—CONCRETE FLOOR SYSTEMS AND THEIR CHARACTERISTICS

THE choice of a type of concrete floor for any specific use involves the careful consideration of points characteristic of each system. Intelligent comparisons may then be made and selection of a suitable, economical floor becomes a relatively simple matter. The elimination of types not inherently adapted to the proposed use reduces the number for which comparative cost studies should be made.

The most important points to be considered are:

I. Use of Floor

1. Loading.
   a. Light or heavy.
   b. Uniform or concentrated.
2. Span.
   a. Long or short.
   b. Regularity of support arrangement.
3. Freedom from obstruction.
   a. Columns.
   b. Beams or girders.
   c. Incorporation of pipes, conduits or vent shafts.
4. Rigidity and resistance to:
   a. Machinery shocks.
   b. Outside vibrations.
   c. Wind stresses or earthquakes.
5. Adaptability to alteration.
   a. Main members.
   b. Secondary members.

6. Conformity to code.
   a. City or other local codes.
   b. Fire or other insurance codes.
7. Insulation.
   a. Sound.
   b. Heat or cold.
8. Acoustical properties.

II. Cost of Floor

1. First cost.
2. Maintenance cost.
3. Indirect cost. (Affecting cost of remainder of building.)
   a. Ability to "tie in" to structure.
   b. Difference in weight and story height as affecting size and cost of supporting columns and foundations.
4. Royalty costs of patented types.
5. Salvage of formwork.

III. Appearance of Floor

1. Floor finish.
   a. Integral concrete.
   b. Any finish applied later.
2. Ceiling finish.
   a. Exposed and untreated.
   b. Plaster.
   c. Paint.

IV. Local Building Conditions

1. Material.
   a. Supply, including freight rate.
   b. Handling on the job.
   c. Storage space.
2. Labor.
   a. Type available.
   b. Possibility of importation.
   c. Labor restrictions.
3. Special conditions of bidding by contractors.
4. Climatic conditions.

V. Time Requirements

1. Speed of construction as affecting revenue of the building.
2. Delays caused by purchase of special materials not available locally.

VI. Supervision

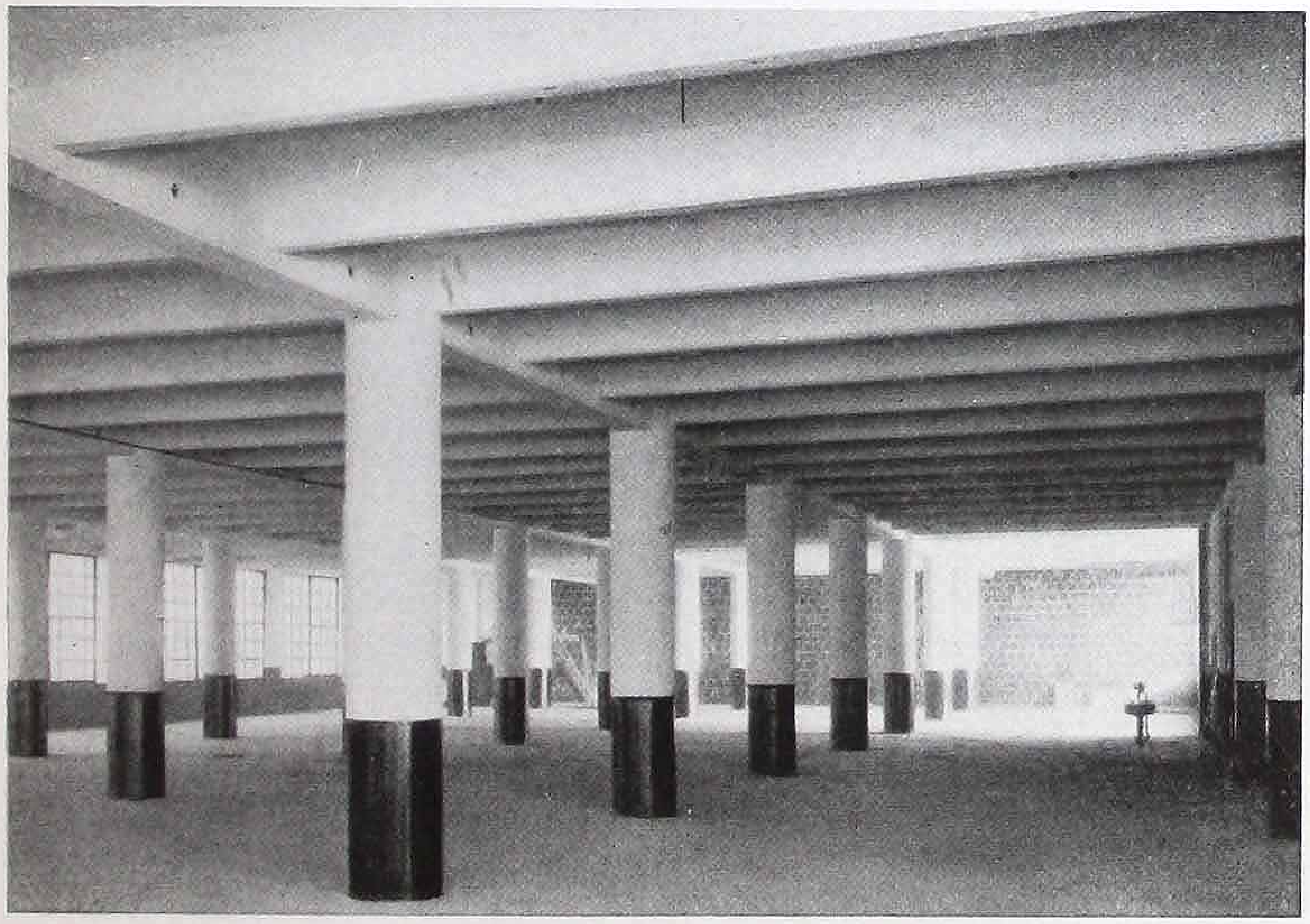
1. Normal.
2. Extra rigid, due to unusual or new system involved.
3. Ease of repairing the result of slight errors or omissions, without reducing factor of safety.

Several of the more commonly used systems are enumerated in the pages to follow, with descriptions, general characteristics and advantages for special purposes or unusual conditions. To facilitate discussion and without intention of fixing definite limits, live loading for floors, as referred to in this review, will be divided into three groups and defined as light (from 40 or 50 to 100 p.s.f.*), intermediate (100 to 175 p.s.f.) and heavy (any live load in excess of 175 p.s.f.).

One-Way Solid Slab

Concrete slabs of uniform depth, with no filler material, and with the main reinforcement in one direction only, are called one-way solid slabs. The term "flat slab" is often erroneously applied to such slabs.

*p.s.f. is an abbreviation of "pounds per square foot."



One-way solid slab construction produces rigid, economical floors suitable for industrial plants and buildings of other occupancy.

Constructed in this manner such slabs constituted the earliest application of concrete to a floor system. They have many good points which make them *suitable and economical when used for supporting intermediate and heavy loads on comparatively short spans*, say, from 6 to 12 ft. long. For light loads these spans may be increased to 14 or 15 ft.

Construction progresses rapidly, as all of the materials used are easily procured, and only ordinary labor and normal supervision are necessary.

Solid slabs produce a stiff and rigid floor capable of withstanding vibration and shock from machinery or earthquakes, and are adapted to use where heavy concentrated loads must be supported.

They provide an excellent base for concrete floor finishes, are easily kept clean and are allowed a low insurance rate because of their high fire resistive qualities.

Limitations to the use of one-way solid slabs for long spans are due to their comparatively large dead weight. Also, the introduction of more beams than used in other systems may not meet the architectural requirements for the floor layout below. The slab weight may be considerably reduced by the use of lightweight aggregate. This reduction may effect a pronounced saving in the indirect cost of the structure (i.e., in reducing the sizes of columns and footings). Lightweight aggregate also improves heat insulation.

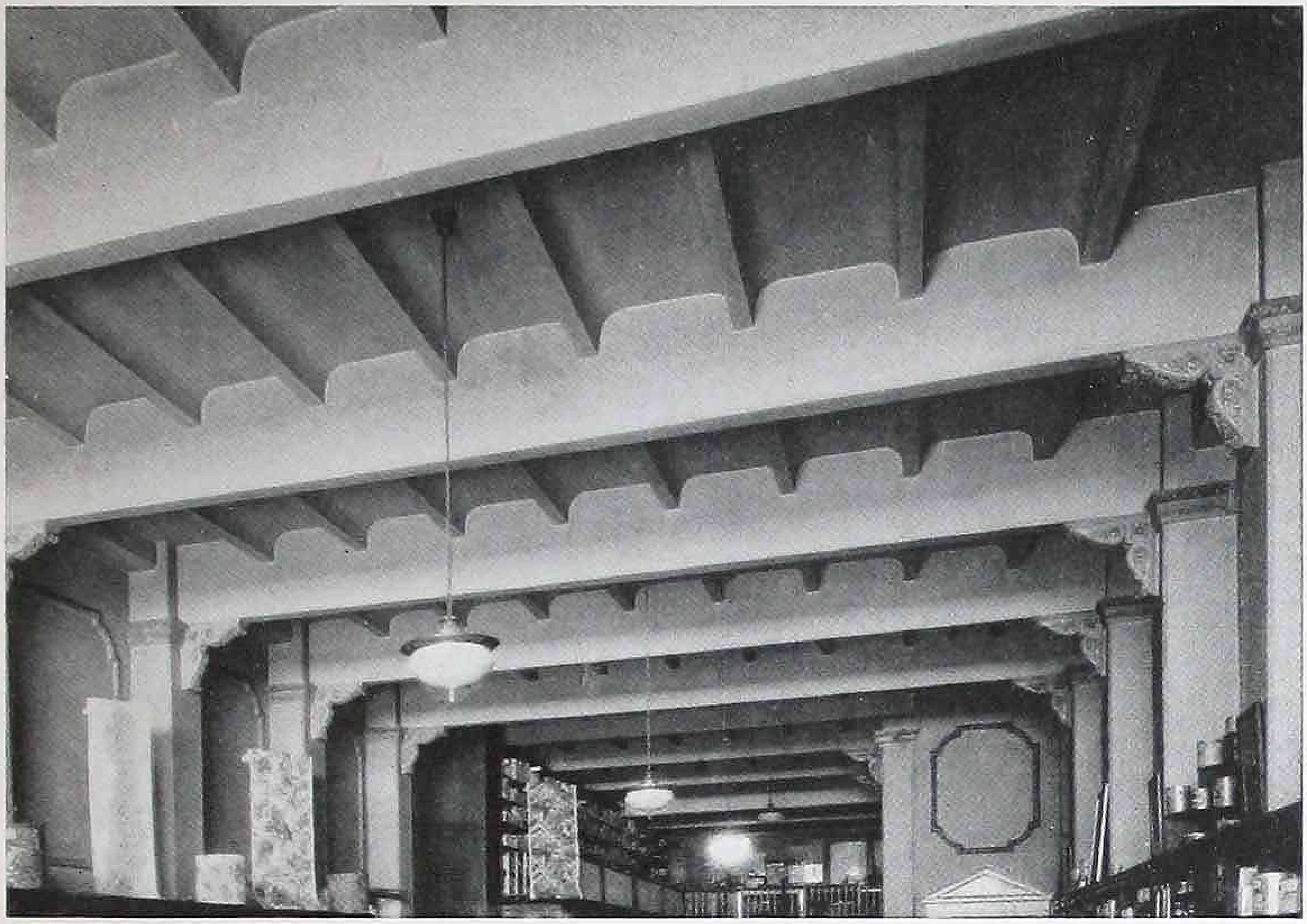
If good tight forms are constructed of pressed wood fiber boards or similar material, plaster may often be omitted, as an attractive ceiling surface results from merely painting or staining the exposed concrete.

Ordinary electric conduits and pipes of about the same size can generally be run in the slab, but mechanical equipment of larger size may require space provided for by either a suspended ceiling or an extra fill between the slab and the finished floor.

One-Way Ribbed Slabs with Block Filler

Hollow filler blocks of lightweight concrete or clay tile, when laid in rows in the bottom of concrete slabs, constitute one form of ribbed slab. The dead load is considerably reduced as compared with a solid slab of equal load carrying capacity although the total depth of slab is increased. The width of the concrete joists, separating the rows of filler and encasing the reinforcement, may be made any desired width to meet the strength requirements. It is customary to include a solid concrete top of two inches or more in depth over the blocks. This serves the double purpose of providing a space for concealing small pipes and conduits and together with the joists gives a T-section, thereby adding considerable strength to them. Introduction of the filler blocks improves sound and heat insulation of slab.

While plaster may be applied directly to the slab, it has been noted that at times a slight discoloration takes place when clay tile filler is used. This is due to the use of materials of different densities and absorption qualities next to one another and may be eliminated by placing tile soffit pieces in the bottoms of the joists to form an all-tile ceiling.



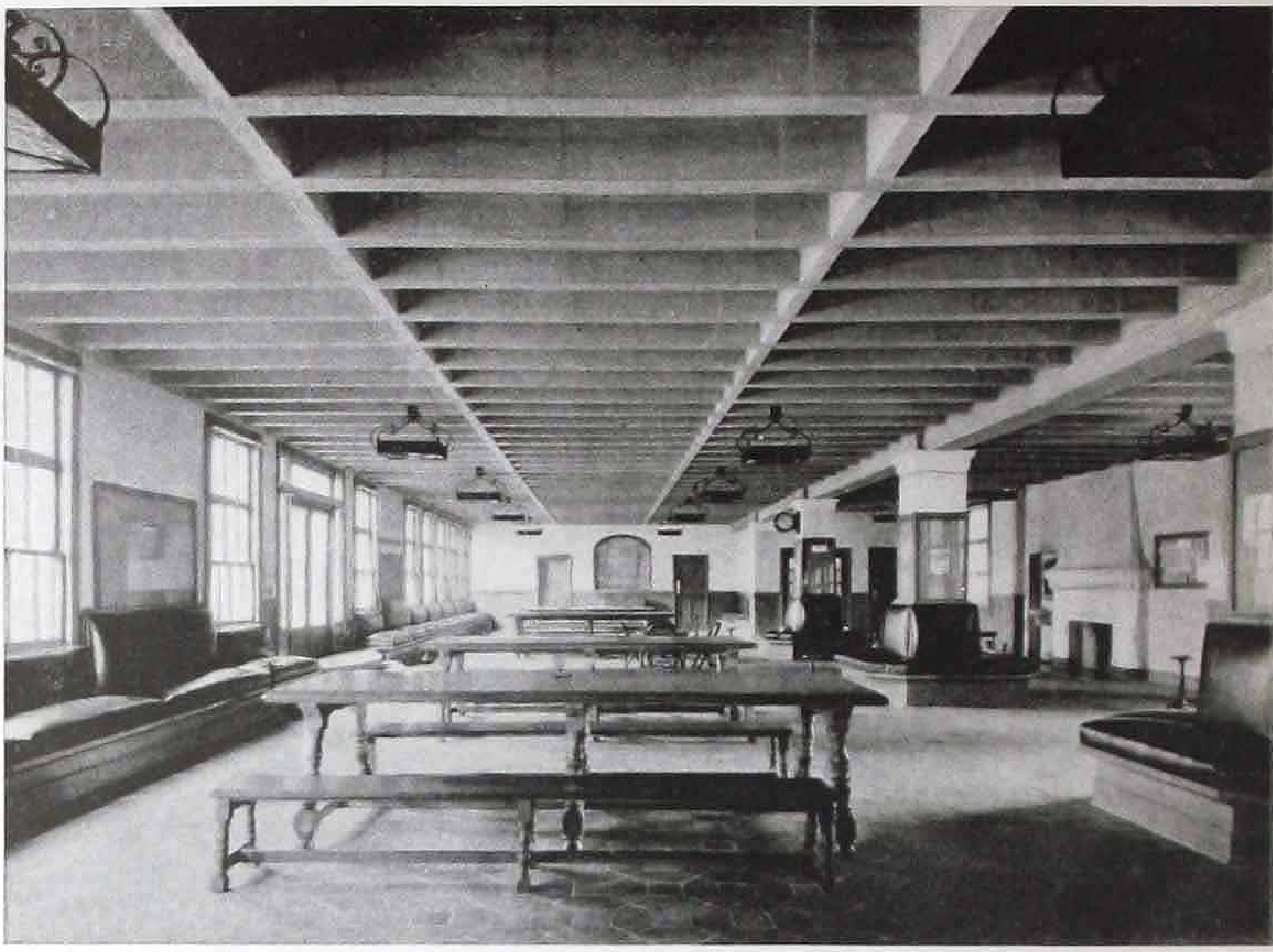
Ribbed slabs constructed with removable metal pans make a lightweight floor of pleasing appearance.

Ribbed slabs of this type are *well adapted to floors of medium span, with light and intermediate loadings.* They cannot carry heavy concentrated loads as well as the solid slabs, and become relatively less economical when the spans are increased.

To insure straight joists, care should be taken that the filler blocks are maintained accurately in line. Owing to the porous nature of the blocks, they should be thoroughly sprinkled to prevent absorption of the water in the concrete, particularly in warm weather.

One-Way Ribbed Slabs with Metal Pans

One of the lightest types of concrete floors results from the use of metal pan fillers between concrete joists. Numerous kinds of such pans are available. Some are fabricated of light gauge material and are intended to be left in place. They may be procured with metal lath already attached at the bottom, upon which plaster may be applied directly. Other pans are made of heavier metal and are removed when the forms are stripped, to be used again or returned to the owner, if leased. Both styles are furnished with either straight or tapered closed ends. Tapered pans are highly desirable on long spans, as with their use the width of the joists is increased at points where such width is needed, namely, near the supports where the shearing stresses are highest. The usual width of metal pans is 20 inches, although 10, 15 and 30-in. pans are generally available.



Ribbed slabs often have spreader joists at third points of long spans. They are economical for light loads.

Metal pan ribbed floors reach their highest economy on long spans with light loads. While the weight is very light, the depth of the floor produces great rigidity. Formwork is economical, merely requiring a board under each rib or joist, with the space under the pans left open.

These floors are not so well suited to support concentrated loads, as the topping between joists is comparatively thin ($2\frac{1}{2}$ to 3 inches). Care must be taken to reinforce the topping across construction joints to prevent these joints from opening.

Two-Way Solid Slab

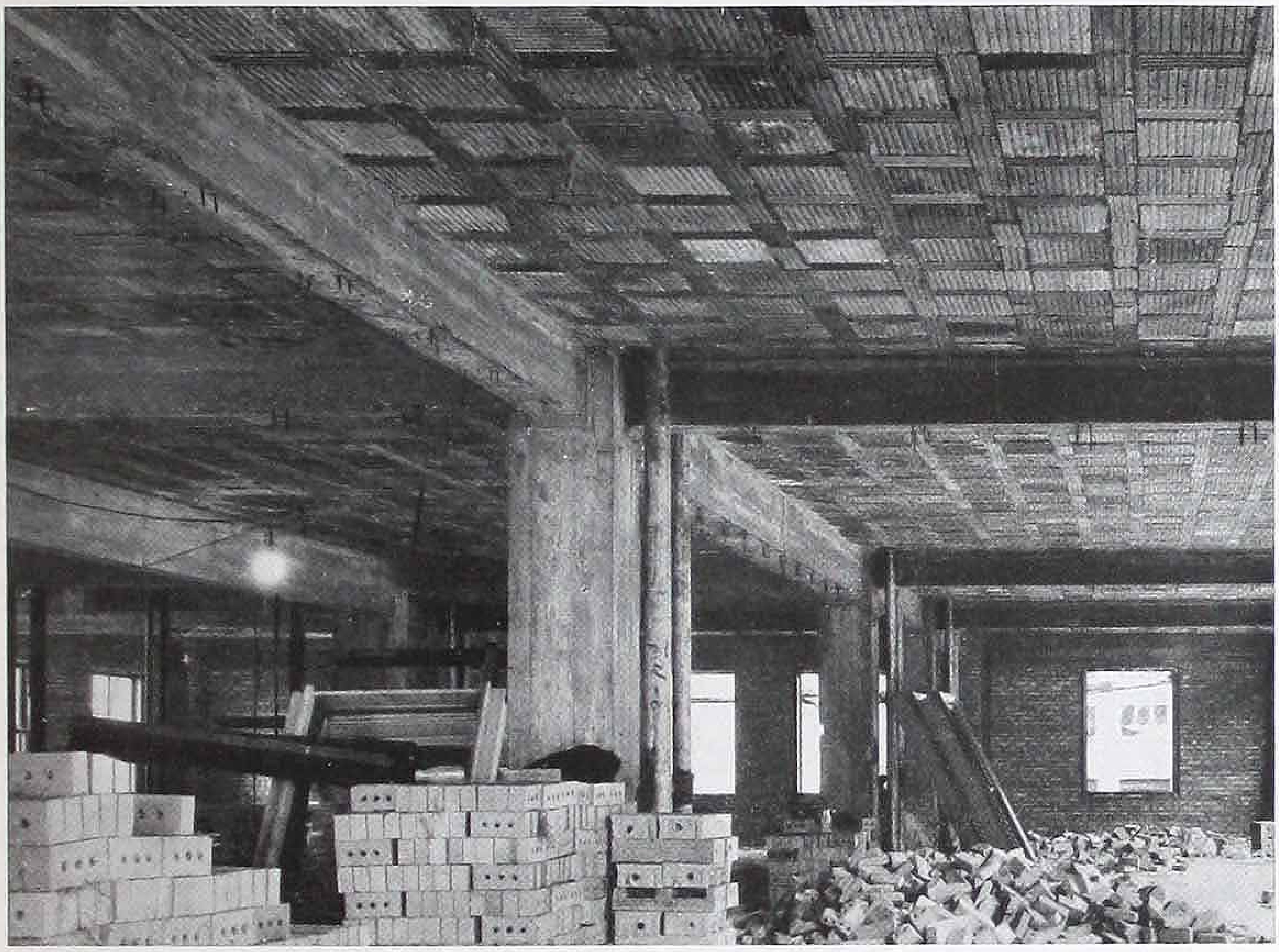
Solid concrete slabs reinforced in two directions, and carrying load both ways to marginal beams, offer a system that is quite economical for certain uses and has other decided advantages. Modern building codes present improved design methods which make this type of floor economical and *well suited to support intermediate and heavy loads on spans up to about 30 ft.* Best results are obtained when panels are nearly square, although panels having a ratio of long to short sides of 2 to 1 may be designed.

Marginal beams framing in two directions to columns, while presenting possible architectural difficulty as to floor layout below, produce effective horizontal bracing. Wind and earthquake forces as well as vibrating machinery loads are properly resisted, and the slab is well suited to carry heavy concentrated loads through so-called "plate action."

Other advantages of the two-way slab are its high fire-resistive qualities, simplicity of formwork and ease of erection. If lightweight aggregate is used, the dead load may be reduced about 30%. This reduction will be reflected in lowering the indirect costs throughout the building structure.

Two-Way Ribbed Slabs with Block Filler

The introduction of hollow filler blocks of lightweight concrete or clay tile, with concrete joists running in both directions, results in *a type of floor having nearly all the advantages of both the one-way ribbed slab and the two-way solid slab.* Dead load is considerably reduced, but the total floor



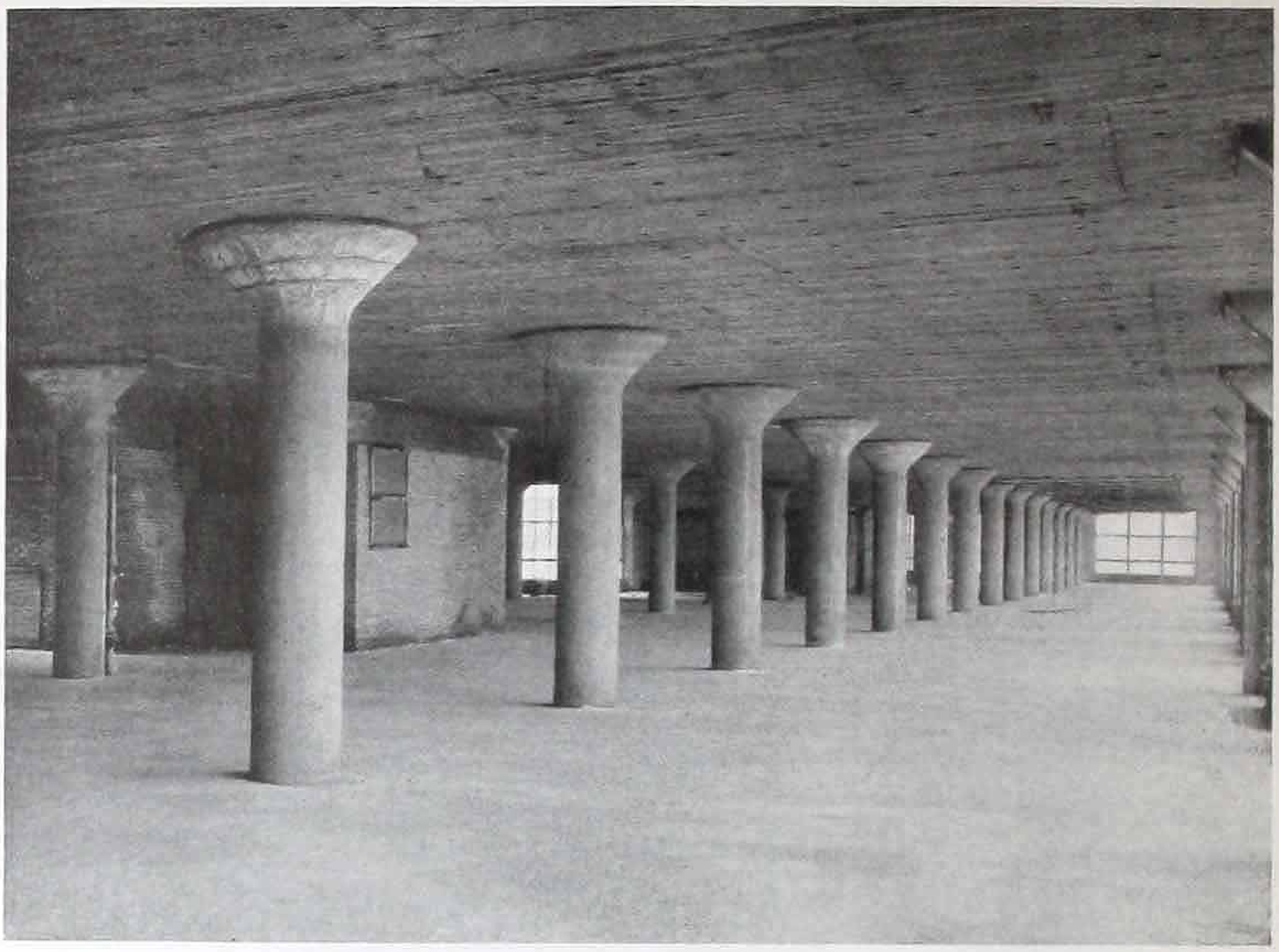
One-way and two-way ribbed slabs with block fillers produce good surfaces for plastering. Note the soffit blocks beneath the concrete ribs.

thickness is increased. Care should be taken with this type, if clay tile filler is used, that the concrete is of such consistency as not to flow into and fill up the cells in the tile.

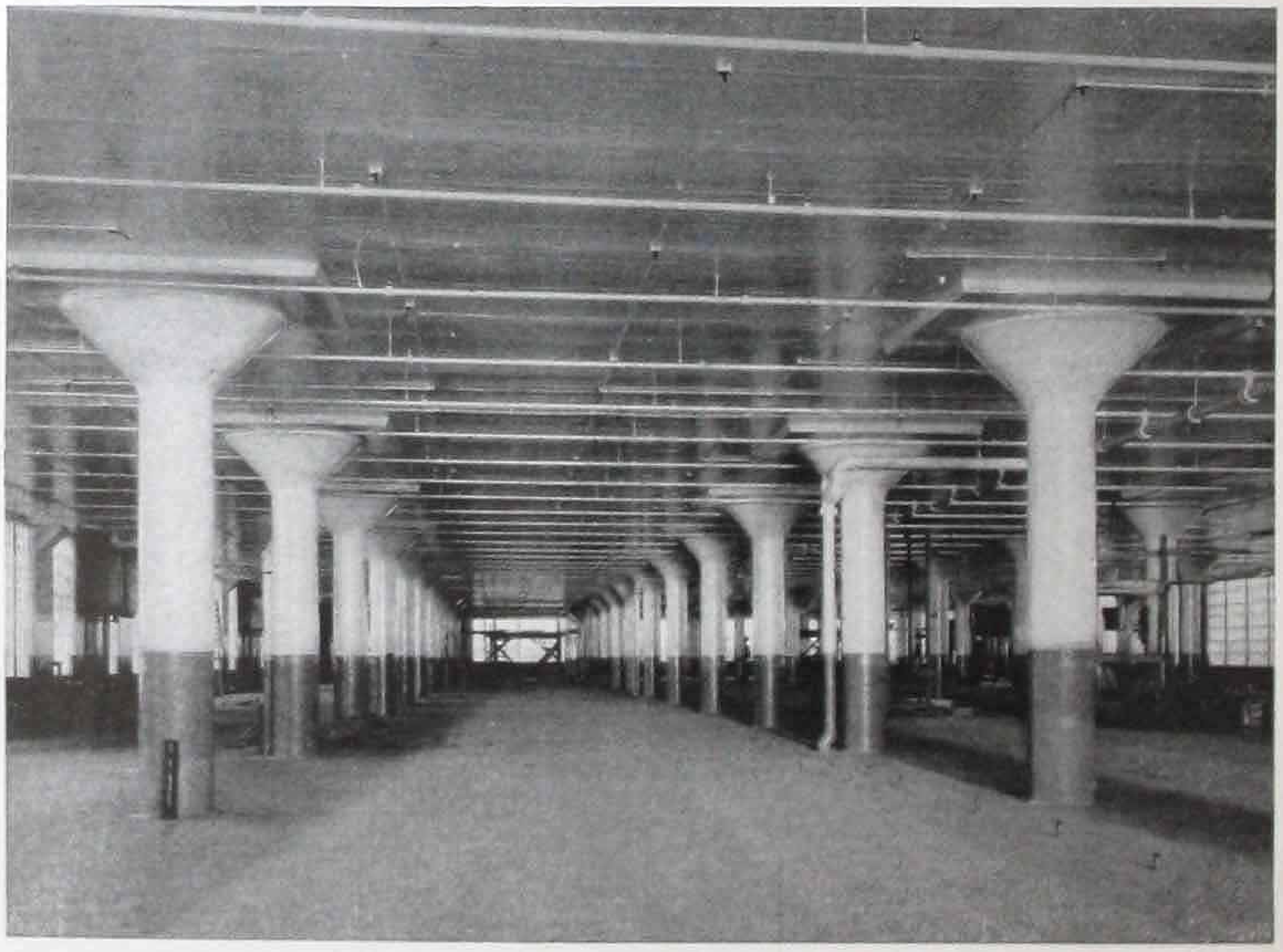
Other remarks made for one-way ribbed slabs with block filler will in general apply to the two-way ribbed slabs.

Girderless or "Flat Slab" Floors

Solid concrete slabs reinforced in two or more directions, but without marginal beams of any kind, are called "flat slabs." They have all *the economy, high efficiency and rigidity of the two-way slabs* previously men-



Maximum story height without obstruction is obtained with flat slab floor construction.



Painted flat slab ceilings are suitable for department stores and industrial buildings and are economical for the heaviest loads.

tioned, *but in even higher degree*. The absence of beams offers the additional advantages of better lighting, ventilation and arrangement of mechanical equipment if used in factory types of buildings. It is customary to employ supporting columns with flared heads or capitals. Also in some cases, it will be found that economy results from the use of panels of additional thickness at each column, called "drop panels."

Flat slabs make rigid, *efficient floors for* such heavy and concentrated loads as are encountered in *warehouses, loft buildings* and *industrial buildings with heavy* or *vibrating machinery*. Panels of medium span and nearly square are preferable. The slab must be made continuous over two or more spans.

Being girderless, the flat slab requires the simplest formwork only and is given a high fire-resistive rating due to the absence of projecting corners or edges. Story heights may be considerably reduced on account of the greater available clear ceiling height.

Summary

While the previously described floors by no means exhaust the available types from which to choose, it will be found that in the majority of cases, at least one of those mentioned will provide an adequate, suitable and economical system; one that will give many years of service at a negligible maintenance cost.

SECTION II—ELEMENTS OF DESIGN

Prior to the actual design of a floor, the designer should be thoroughly familiar with the structural provisions of the building code he is to use. The safe load tables and other data given in this section and in Section III are based on provisions of the Tentative Building Regulations for Reinforced Concrete, American Concrete Institute,* referred to hereafter as the A. C. I. code, and concrete having an ultimate compressive strength of 2,000 p.s.i.** at an age of 28 days. This concrete has an allowable unit stress of 800 p.s.i. on the extreme fiber, with an increase to 900 p.s.i. on the extreme fiber adjacent to supports of continuous or fixed beams and slabs. The unit stress of the reinforcement is taken at 20,000 p.s.i. in tension, and $n = 15$. The shearing stress in the concrete is limited to 40 p.s.i. without web reinforcement and bond stress to 100 p.s.i. for deformed bars. Allow-

*Report of American Concrete Institute Committee 501, Standard Building Code, adopted by the Institute at its 32nd annual convention, Feb. 1936, as a tentative standard.

**p.s.i. is a generally accepted abbreviation of "pounds per square inch."

able tensile stress in the web reinforcement is taken at 20,000* p.s.i. In all cases, the amount of protective covering of the reinforcing steel is shown in the tables. Bending moments and shears for continuous beams and slabs with uniform load are given in Table 1.

TABLE No. 1—BENDING MOMENTS IN SLABS, BEAMS AND GIRDERS FOR UNIFORM LOADS

Coefficients of wl^2

Number and Length of Spans		End Spans		Intermediate Spans	
		$+M$ at center	$-M$ at 2nd support	$+M$ at center	$-M$ at support
Spans equal to or less than 10 ft.	Two spans	1/10	1/10	....	....
	More than two spans	1/10	1/12	1/12	1/12
Spans greater than 10 ft.	Two spans	1/10	1/8	....	....
	More than two spans	1/10	1/10	1/12	1/12

Note: Shear in end members at the 2nd support is 1.20 $\frac{wl}{2}$ and the shear at all other supports is $\frac{wl}{2}$

For bending moments and shears in continuous girders with concentrated loads, the coefficients given in Figure 1 are used.

The coefficients in Table 1 and Figure 1 may be used for spans in which the longer of two adjacent spans does not exceed the shorter by more than 20 per cent, and in which the intensity of the live load is not more than three times the intensity of the dead load. In these cases, l equals the average of two adjacent clear span lengths for negative moment and the applicable clear span for positive moment.

Negative reinforcement to be provided at the outer end of all members built integrally with their supports shall be not less than 0.005 $b'd$ for T-beams and 0.005 bd for rectangular beams and slabs.

A. C. I. Code recommendations with regard to "slabs supported on four sides" are the basis of values in the tables of two-way solid slabs. They take into account the condition of continuity of the slab, the ratio of the long side to the short side in rectangular panels, and the so-called "plate action" of the slab.

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*See footnote** on page 22.

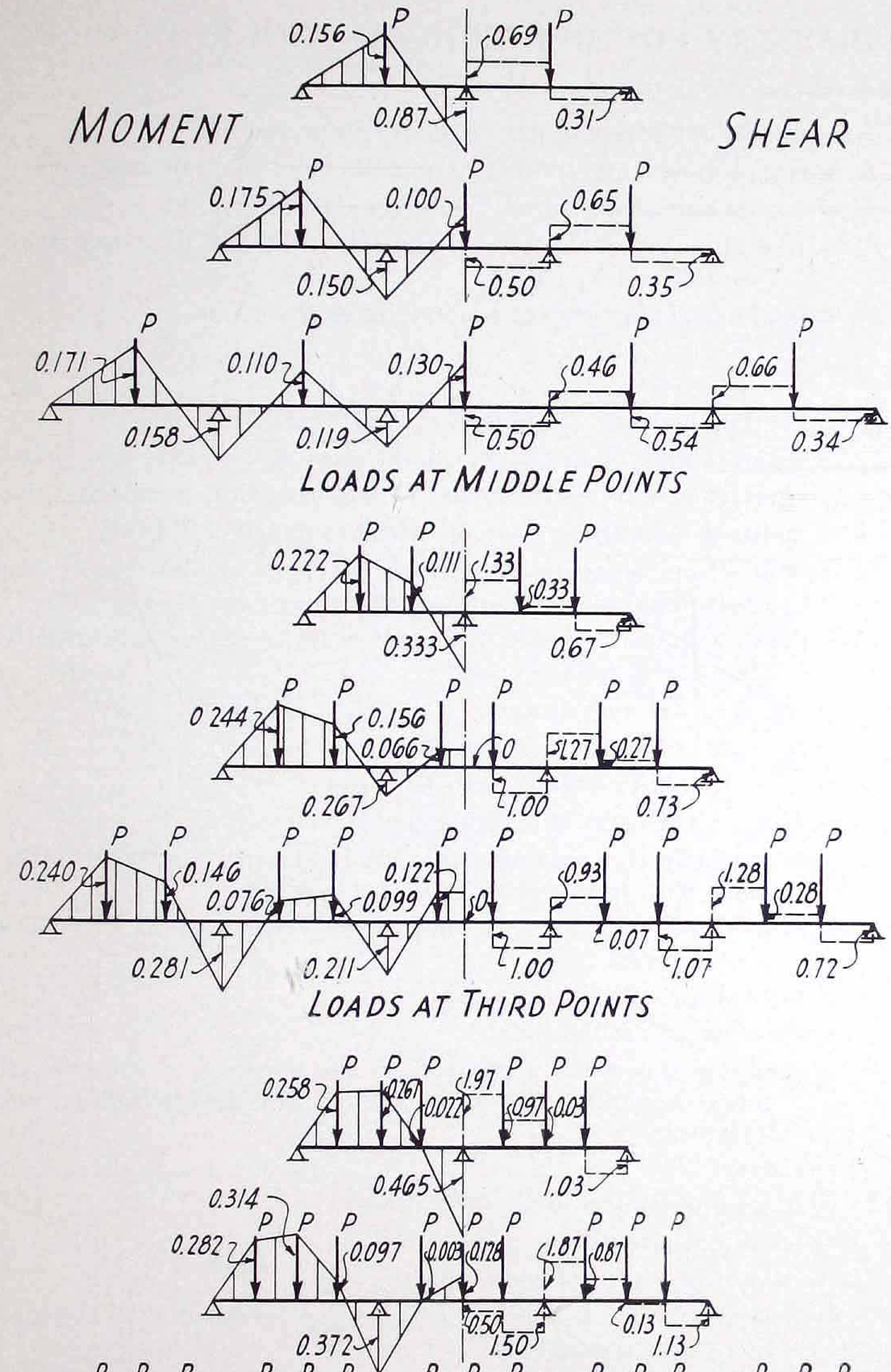

MOMENT
SHEAR
0.156
P
0.69
0.187
0.31
0.175
0.100
0.65
0.150
0.50
0.35
0.171
0.110
0.130
0.46
0.66
0.158
0.119
0.50
0.54
0.34
LOADS AT MIDDLE POINTS
0.222
0.111
1.33
0.33
0.333
0.67
0 244
0.156
0.066
0
1.27
0.27
0.267
1.00
0.73
0.240
0.146
0.076
0.099
0.122
0
0.93
1.28
0.28
0.281
0.211
1.00
0.07
1.07
0.72
LOADS AT THIRD POINTS
0.258
0.261
0.022
1.97
0.97
0.03
0.465
1.03
0.314
0.282
0.097
0.003
0.128
1.87
0.87
0.372
0.50
1.50
0.13
1.13
0.303
0.277
0.006
0.155
0.079
0.204
1.40
0.40
1.89
0.89
0.079
0.054
0.394
0.296
0.050
1.50
0.60
1.60
0.11
1.11
LOADS AT MIDDLE AND QUARTER POINTS

Fig. 1

FORMULAS FOR REINFORCED CONCRETE DESIGN

Standard Notation

f_s = tensile unit stress in longitudinal reinforcement.

f_c = compressive unit stress in extreme fiber of concrete in flexure.

f_v = tensile unit stress in web reinforcement.

E_s = modulus of elasticity of steel in tension or compression (= 30,000,000 p.s.i.).

E_c = modulus of elasticity of concrete in compression.

$n = \dfrac{E_s}{E_c}$

M = bending moment or moment of resistance in general.

A_s = effective area of reinforcement in tension in beams and slabs.

A_s' = effective area of reinforcement in compression in beams and slabs.

b = width of rectangular beam or width of flange of T-beam.

d = depth from compression surface of beam or slab to center of longitudinal tensile reinforcement.

d' = depth from compressive surface of beam to center of longitudinal compressive reinforcement.

b' = width of web in T-beams.

t = thickness of flange in T-beams.

k = ratio of depth of neutral axis to depth d.

j = ratio of lever arm of resisting couple to depth d.

p = ratio of effective area of tensile reinforcement to effective area of concrete in beams or slabs = $A_s \div bd$.

p' = ratio of effective area of compressive reinforcement to effective area of beam.

V = total shear.

v = shearing unit stress.

v_c = shearing unit stress permitted on the concrete of the web; the value depending on the anchorage of the longitudinal reinforcement.

$v' = v - v_c$.

Σo = sum of perimeters of a group of bars.

u = bond unit stress.

l = clear span length of beam or slab.

s = spacing of vertical stirrups, measured perpendicular to the direction of the stirrup.

a = distance along the length of beam in which web reinforcement is required, measured from the face of support.

w = uniformly distributed load per unit of length of beam or slab.

P = concentrated load.

1. Rectangular Beams and Slabs

$$k = \sqrt{2pn + (pn)^2} - pn = \frac{1}{1 + \frac{f_s}{nf_c}}$$

$$j = 1 - \frac{k}{3}$$

$$p = \frac{A_s}{bd} = \frac{\frac{1}{2}}{\frac{f_s}{f_c}\left(\frac{f_s}{nf_c} + 1\right)} = \frac{f_c k}{2f_s}$$

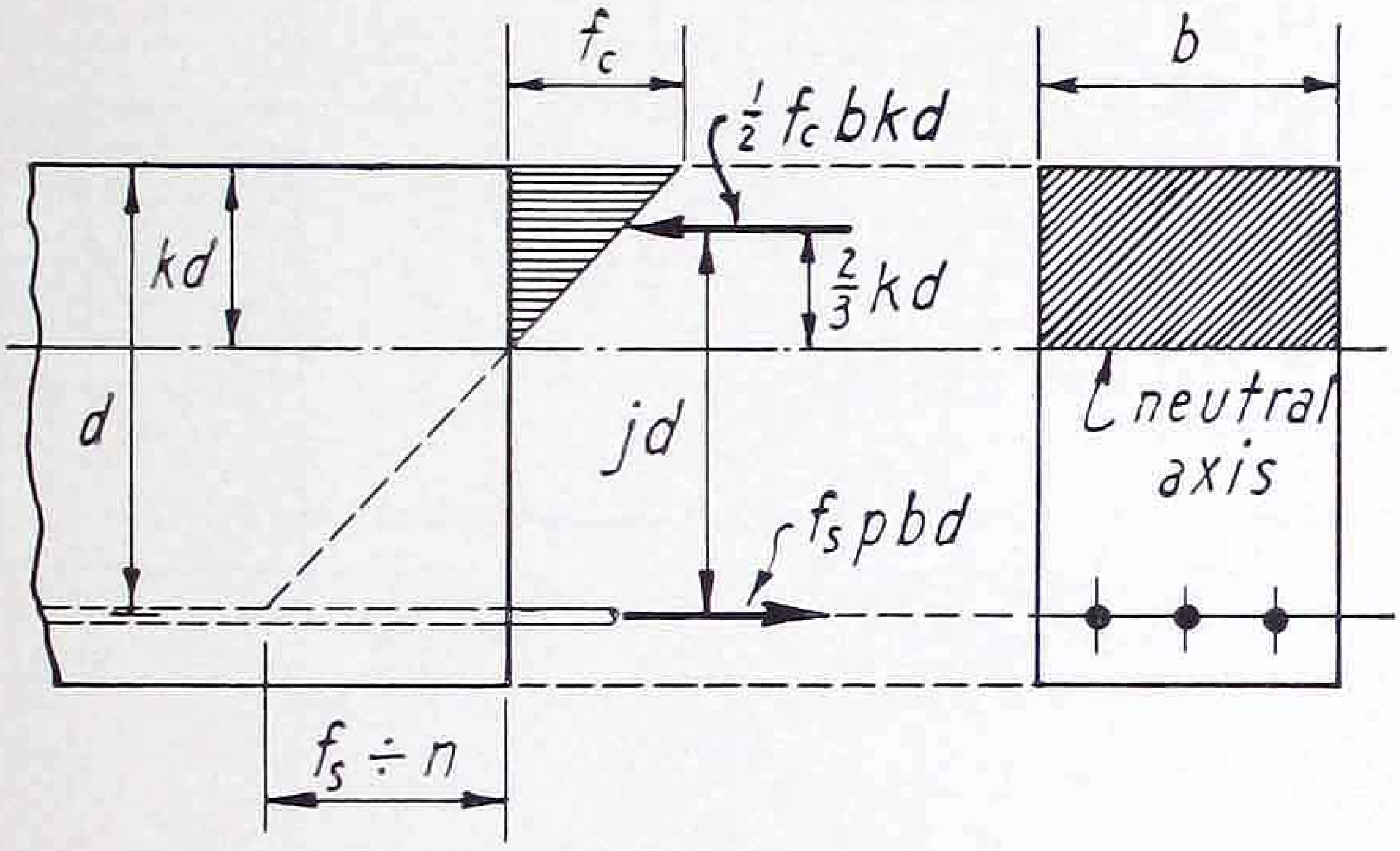


Fig. 2

$$K = \tfrac{1}{2} f_c kj \text{ or } pf_s j$$

$$M = \tfrac{1}{2} f_c kjbd^2 = Kbd^2 \text{ or } bd^2 = \frac{2M}{f_c kj} = \frac{M}{K}$$

$$M = pf_s jbd^2 \text{ or } bd^2 = \frac{M}{pf_s j}$$

$$A_s = \frac{M}{f_s jd} \text{ or } f_s = \frac{M}{A_s jd}$$

$$f_c = \frac{2f_s p}{k} \text{ or } \frac{f_s k}{n(1 - k)} \text{ or } \frac{2M}{kjbd^2}$$

2. *Rectangular Beams Reinforced for Compression*

$$k = \sqrt{2n\left(p + p'\frac{d'}{d}\right) + n^2(p + p')^2} - n(p + p')$$

$$z = \frac{\frac{1}{3}k^3d + 2p'nd'\left(k - \frac{d'}{d}\right)}{k^2 + 2p'n\left(k - \frac{d'}{d}\right)}$$

$$jd = d - z$$

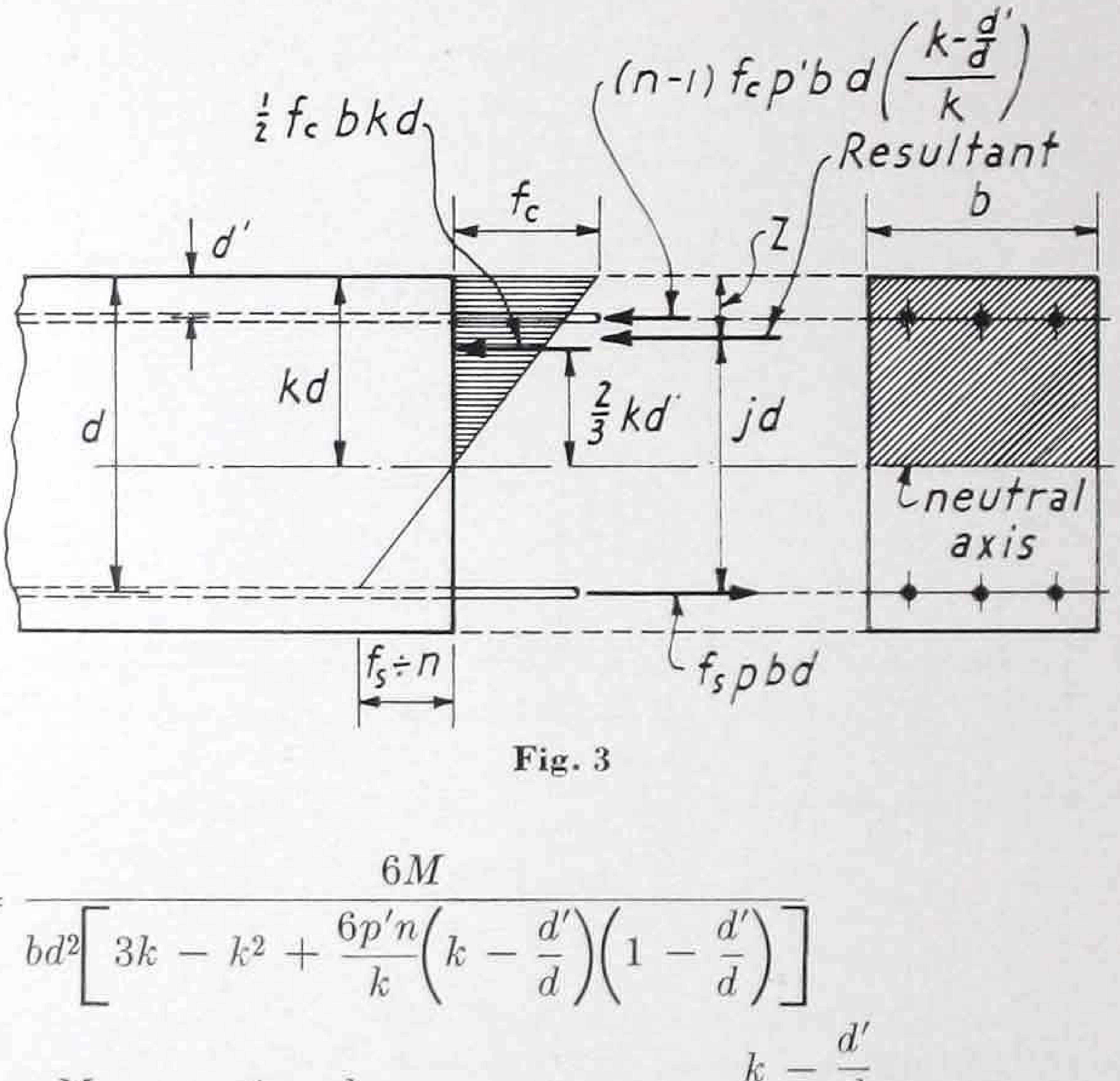


Fig. 3

$$f_c = \frac{6M}{bd^2\left[3k - k^2 + \frac{6p'n}{k}\left(k - \frac{d'}{d}\right)\left(1 - \frac{d'}{d}\right)\right]}$$

$$f_s = \frac{M}{pjbd^2} = nf_c\frac{1 - k}{k} \qquad f'_s = nf_c\frac{k - \frac{d'}{d}}{k}$$

$$A_s = \frac{M}{f_s jd} \text{ or } pbd \qquad A_s' = p'bd$$

$$M = Kbd^2 \qquad d = \sqrt{\frac{M}{Kb}}$$

$$p = \frac{f_c}{f_s}\left[\frac{k}{2} + \frac{n - 1}{k}\left(k - \frac{d'}{d}\right)p'\right]$$

$$K = f_c\left(\frac{k}{2} - \frac{k^2}{6} + \frac{n - 1}{k}p'\left[(1 - k)\left(k - \frac{d'}{d}\right) + \left(k - \frac{d'}{d}\right)^2\right]\right)$$

3. *T-Beams*

Case I. When the neutral axis lies in the flange, use the formulas for rectangular beams.

Case II. When the neutral axis lies in the web. The amount of compression in the web is commonly small compared with that in the flange and is neglected in the following formulas:

$$k = \frac{1}{1 + \frac{f_s}{nf_c}} \qquad k = \frac{pn + \frac{1}{2}\left(\frac{t}{d}\right)^2}{pn + \frac{t}{d}}$$

$$kd = \frac{2ndA_s + bt^2}{2nA_s + 2bt} \qquad d - jd = \frac{3kd - 2t}{2kd - t} \times \frac{t}{3}$$

$$j = \frac{6 - 6\left(\frac{t}{d}\right) + 2\left(\frac{t}{d}\right)^2 + \left(\frac{t}{d}\right)^3\left(\frac{1}{2pn}\right)}{6 - 3\left(\frac{t}{d}\right)}, \text{ or } j = 1 - \frac{t}{d}\left(\frac{3k - 2\,t/d}{6k - 3\,t/d}\right)$$

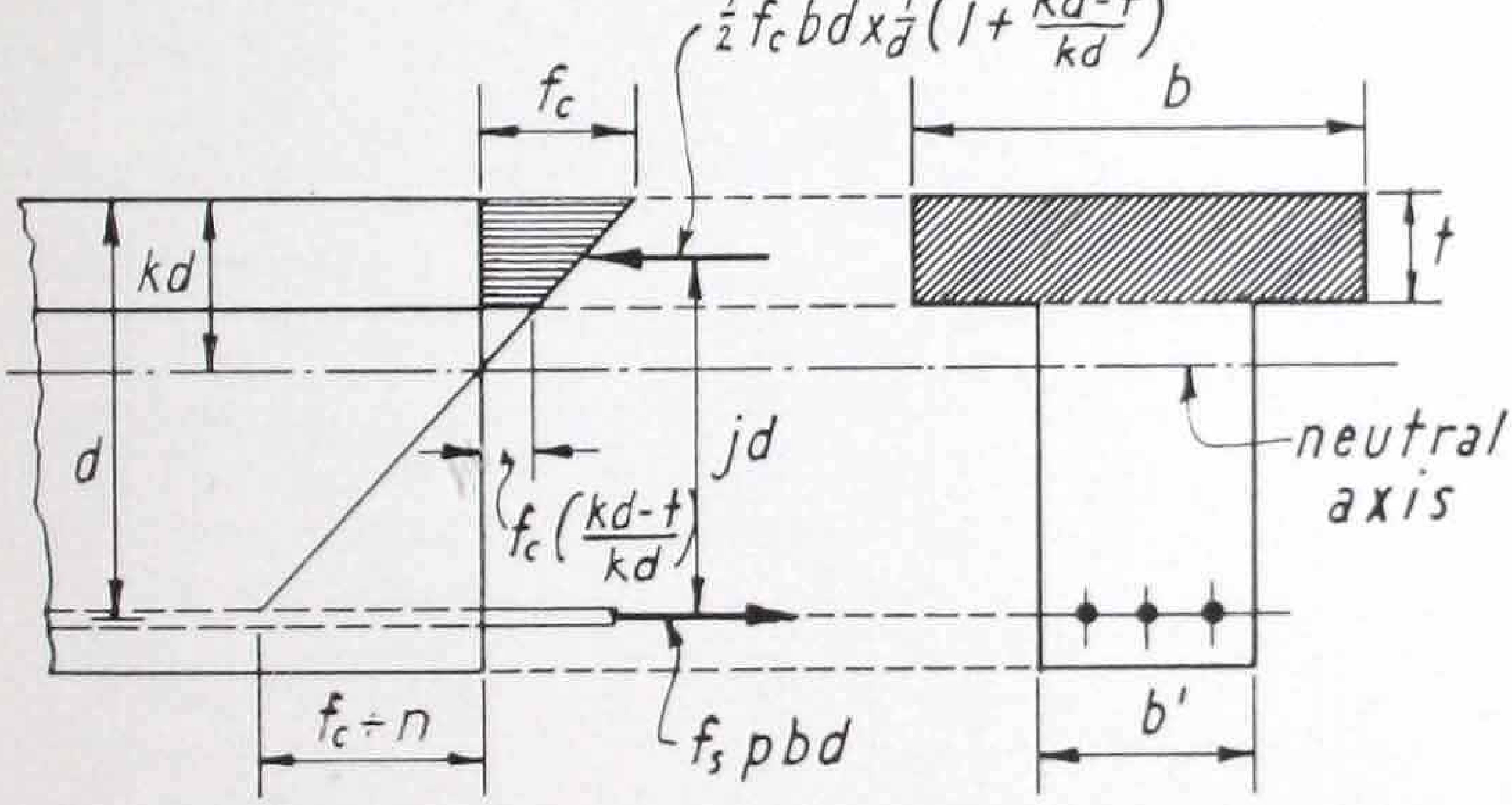


Fig. 4

$$f_s = \frac{M}{A_s jd} = \frac{M}{pjbd^2} \qquad f_c = \frac{f_s k}{n(1-k)}$$

$$M = f_s A_s jd \qquad M = f_c\left(1 - \frac{t}{2kd}\right) bt \times jd$$

4. *Shear and Web Reinforcement*

$$v = \frac{V}{bjd} \text{ (for rectangular beams)}$$

$$v = \frac{V}{b'jd} \text{ (for T-beams)}$$

$$a = \frac{l}{2}\left(\frac{v'}{v}\right)$$

5. *Bond*

$$u = \frac{V}{\Sigma ojd} = \frac{vb}{\Sigma o} \text{ or } \Sigma o = \frac{V}{ujd}$$

Illustrative Examples

Computations for typical problems are given, using the tables in Section III and design data in this section as a basis, and following through to an estimate of the material quantities for each system. The computations are made by slide-rule. It is urged that the designer familiarize himself with each step, in order that he may learn the correct use of the tables.

Problem 1

Given an interior panel 18 ft. by 24 ft. with the following superimposed load:

Partitions	= 20 p.s.f.
Floor Finish	= 12 p.s.f.
Live Load	= 50 p.s.f.
Total	82 p.s.f.

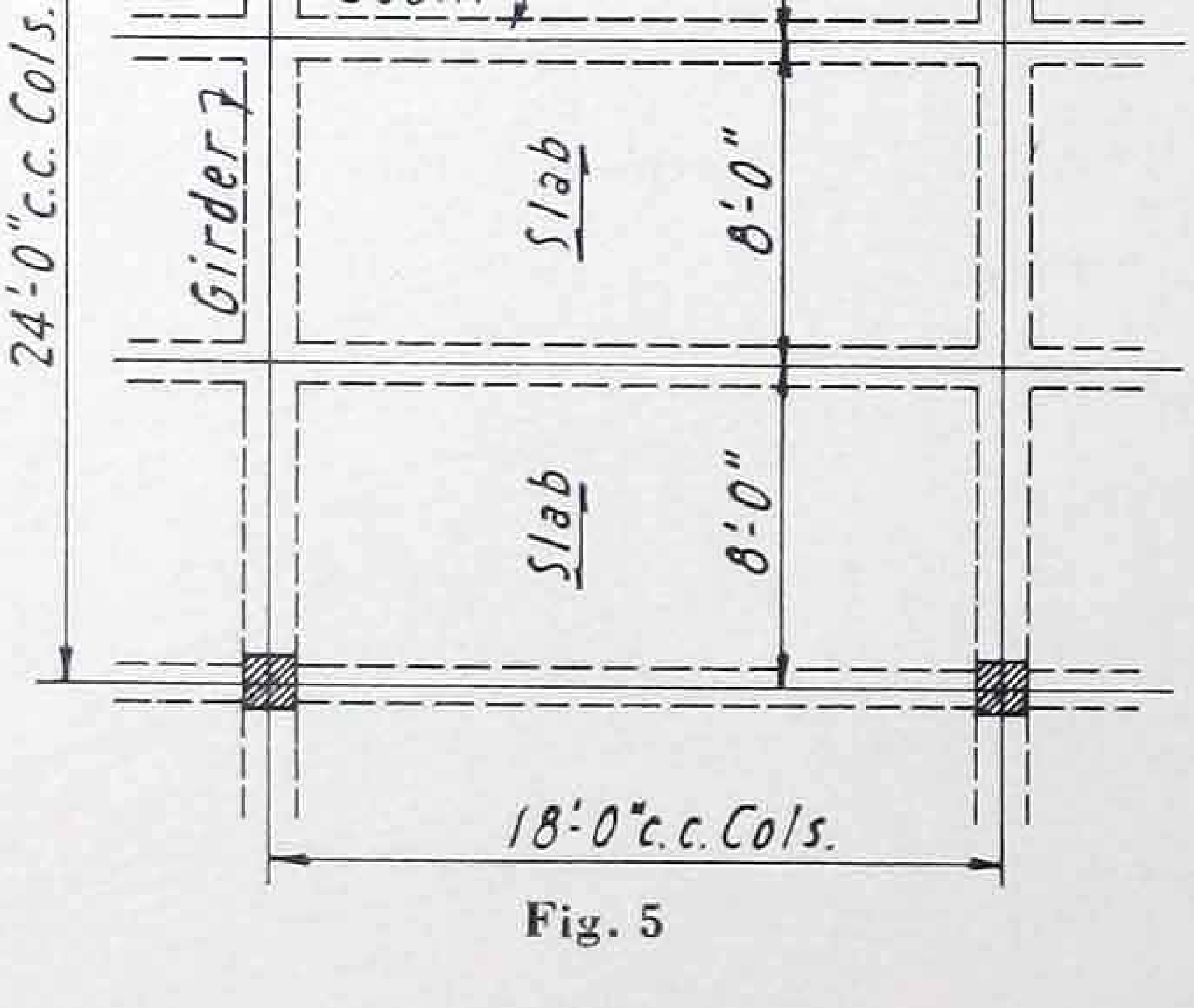


Fig. 5

If ceilings are plastered the weight of lath and plaster should be included in the total floor load.

Design a solid one-way slab, using intermediate beams framing into girders on column centers, as shown in Figure 5.

Clear slab span equals 8 ft. less width of beam, say 7 ft. Refer to Table No. 7. Down the column for spans of 7 ft. and opposite the line denoting an interior span, it will be found that the nearest (heavier) load is 98 p.s.f. This requires a slab 3 in. thick. However, in order to provide adequate

space for conduits and reinforcement a 3½ in. thick slab will be used for which the allowable safe load is 167 p.s.f.

Use 3½-in. slab. This slab weighs 44 p.s.f. making a total dead and live load of 82 + 44 = 126 p.s.f.

Then the area of steel required in a strip of slab one foot wide =

$$\frac{126}{167 + 44} \times 0.23 \text{ sq. in.} = 0.14 \text{ sq. in.}$$

According to Table No. 6, ⅜-in. rd. bars spaced 8½ inches on centers satisfies this requirement, but for bond Σo must equal

$$\frac{126 \times \frac{1}{2}(8.00 - 0.84)}{100 \times \frac{7}{8}(3.50 - 0.75 - \frac{1}{2} \times 0.375)} = 2.02 \text{ in.}$$

*Use ⅜-in. rd. bars at 7-in. o.c.** Bend alternate bars over the beams and continue them in the top of the slab for a distance of one-fourth of the next span length (or in this case 2 ft. beyond the center line of the beam) on each side, as shown in Figure 6.

Reinforcement for temperature and shrinkage at right angles to main steel is also required. The spacing shall not exceed five times the depth of the slab or 18-in. The area of steel shall not be less than 0.002 bd with deformed bars or 0.0025 bd with plain bars. Use deformed bars. A_s = 0.002 × 3½ × 12 = 0.084 sq. in. Use ⅜-in. rd. bars spaced 15 in. o.c. The maximum allowable spacing is not exceeded.

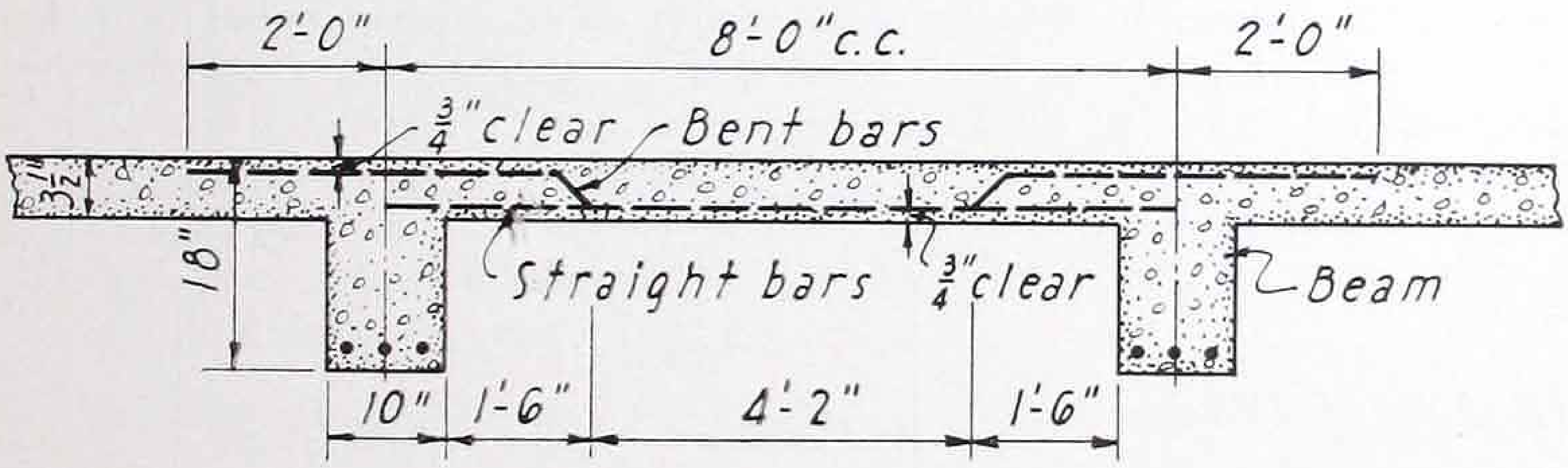


Fig. 6

Design of Beams

Each beam carries a load of 8(82 + 44) = 1008 lb. per lin. ft. Clear span = say 17 ft. Referring to Table No. 16 (Safe load table of T-beams, interior spans), it will be found that a beam 10 in. by 18 in. is satisfactory. This beam can carry a load of 1200 lb. per lin. ft.

Use 10-in. by 18-in. beam. The stem of the beam weighs 151 lb. per lin. ft., making a total load on the beam of (1008 + 151) = 1159 lb. per ft.

*o.c.—spacing on centers of bars.

$$A_S = \frac{1159}{(1200 + 151)} \times 1.46 \text{ sq. in.} = 1.25 \text{ sq. in.}$$

Use one ¾-in. rd. bar, straight; two ¾-in. rd. bars, bent.

The total end shear equals half the entire load carried by the beam on its *clear* span. Assuming the width of the girders to be 16 inches, the clear span of the beam is 16 ft. 8 in.

Then $V = \dfrac{16.67}{2}(1159) = 9650$ lb. and the unit end shear

$$v = \frac{V}{bjd} = \frac{9650}{10 \times 0.875^{*} \times 16} = 69 \text{ p.s.i.}$$

As this value exceeds the maximum allowable shearing unit stress of 40 p.s.i., take care of the excess by means of web reinforcement, such as stirrups. For their design, refer to the "Diagram for Stirrup Spacing," page 69.

Then $v' = 69 - 40 = 29$ p.s.i. and $v'b = 29 \times 10 = 290$. The distance a over which stirrups are required $= \dfrac{l}{2}\left(\dfrac{v'}{v}\right) = \dfrac{16.67}{2} \times \dfrac{29}{69} = 3.50$ ft. By code requirements, the maximum permissible spacing of stirrups $= \frac{3}{4}d^{**}$ $= 0.75 \times 16 = 12$ in.

Use ⅜-in. rd. U-stirrups. Holding a straight edge on the chart for ⅜-in. rd. U-stirrups, so that it intersects the vertical line at 290 and the horizontal line at 3.50 ft., the spacing is read off at the intersections of the straight edge and the heavy vertical lines. In this case there are no intersections with lines indicating a spacing of 12 or less, so that stirrups are used at the maximum spacing of 12 inches up to a point equal to a. In other words, the spacing is S = *12, 12, 12 in.* Thus three stirrups are required at each end of the beam, or a total of *six* for each beam.

The maximum bond stress should not exceed 100 p.s.i.

$$u = \frac{vb}{\Sigma o} = \frac{69 \times 10}{2.36 \times 4} = 73 \text{ p.s.i.}$$

Design of Girder

Clear span equals 24 ft. less width of column, assumed 16 in., or 22.67 ft. The girder, in addition to its own weight which acts as a uniform load, must support two concentrated loads due to the reactions of the intermediate beams. The load from each beam $= \dfrac{18}{2}\Big[\,8(82 + 44)\Big]$ $+ \dfrac{16.67}{2} \times 151 = 9070 + 1260 = 10330$ lb. or a total concentrated load at the third-points of the girder $= 2 \times 10330 = 20660$ lb.

*See Table No. 3 for exact values of j. For practical purposes j is assumed as ⅞ or 0.875.

**All examples of stirrup design have been based upon a maximum spacing of ¾d and a stress (f_s) of 16000 p.s.i. The 1936 ACI Code, adopted after these examples were set in type, permits a maximum spacing of ½d and a working stress of $f_s = 20000$ p.s.i. To design for a 20000 p.s.i. working stress simply use the proper scale of ordinates in the diagrams on page 69.

Assume the weight of the girder = 375 lb. per lin. ft., uniformly distributed.

Referring to Table 1 and Fig. 1 of Moment Coefficients on Pages 14 and 15 to be used in this case, the equations for maximum moments (both the negative moment at the column and the positive moment at the center of the span) are as follows:

(1) $-M = 0.211 \times 20660 \times 22.67 + \frac{1}{12} \times 375 \times 22.67^2 = 98{,}500 + 16{,}000 = 114{,}500$ ft. lb. $= 1{,}375{,}000$ in. lb.

Assuming a width of girder stem of 16 in., the required effective depth = $\sqrt{\frac{M}{K^*b}} = \sqrt{\frac{1{,}375{,}000}{157 \times 16}} = \sqrt{548} = 23.5$ (say 24 in., or a total depth of 26 in.)

Use 16-in. by 26-in. girder.

$$A_S = \frac{M}{f_S jd} = \frac{1{,}375{,}000}{20{,}000 \times 0.875 \times 24} = 3.28 \text{ sq. in.}$$

(2) $+M = 0.122 \times 20660 \times 22.67 + \frac{1}{12} \times 375 \times 22.67^2 = 57{,}100 + 16{,}000 = 73{,}100$ ft. lb. $= 877{,}000$ in. lb.

Depth of compression flange, $t = 3.5$ in., divided by the effective depth, $d = 24$ in., equals $\frac{t}{d} = 0.15$, in which case the value of j is greater than $\frac{7}{8}$ recommended for rectangular sections, but using $j = \frac{7}{8}$ gives conservative results for A_S.

$$A_S = \frac{877{,}000}{20{,}000 \times 0.875 \times 24} = 2.09 \text{ sq. in.}$$

Use five ¾-in. rd. bars. Bend three bars over the supports and use one ⅞-in. rd. extra bar, 12 ft. long in the top of the girder at the columns. This gives an area of 3.24 sq. in. at this point, where 3.28 sq. in. is required, which is sufficiently close.

The maximum end shear, $V = 20660 + \frac{22.67}{2} \times 375 = 24{,}910$ lb.

$$v = \frac{24{,}910}{16 \times 0.875 \times 24} = 74 \text{ p.s.i.} \qquad v' = 74 - 40 = 34 \text{ p.s.i.}$$

$$v'b = 34 \times 16 = 544$$

The maximum shear at the first intermediate beam $= 20660 + 4.42 \times 375 = 22{,}320$ lb.

$$v = \frac{22{,}320}{16 \times 0.875 \times 24} = 67 \text{ p.s.i.}$$

$$v' = 67 - 40 = 27 \text{ p.s.i.}$$

$$v'b = 27 \times 16 = 432$$

*See Table 3 for values of K.

Use 3/8-in. rd. U-stirrups. The maximum permissible spacing = 0.75d = 18 in.

On the diagram of web reinforcement, page 69, place a mark at a height equal to 432 above a point 6.92* on the a axis. Place a straight edge to connect this point and a point 544 on the $v'b$ axis, and read the stirrup spacing: S = 9 at 6, 3 at 9 in. or, *24 stirrups per girder.*

The bond stress at first intermediate beam, $u = \dfrac{67 \times 16}{11.8} = 91$ p.s.i.

At the support, $u = \dfrac{74 \times 16}{16.91} = 70$ p.s.i.

The depth of the girder designed above may be reduced by providing compressive reinforcement in the bottom of the girder at the supports. For this purpose advantage may be taken of the straight bars used as tensile reinforcement at the center of the span by extending the bars beyond the face of the support far enough to develop the stress in bond.

Assume that two 3/4-in. rd. bars are brought from the other side of the support to provide, with the straight bars in the girder being designed, four 3/4-in. rd. bars, $A'_s = 1.76$ sq. in.

Determine the depth of the girder and the tensile reinforcement required by using the coefficients given in Table 4, and the formulas: $d = \sqrt{\dfrac{M}{Kb}}$; $A_s = pbd$. The values necessary to enter this table are: d is assumed to be 21 in.; $d' = 2.0$ in.; $\dfrac{d'}{d} = 0.10$; $p' = \dfrac{A'_s}{bd} = \dfrac{1.76}{16 \times 21} = 0.0052$.

From the table, interpolating: $K = 201$, $p = 0.0115$

$d = \sqrt{\dfrac{1{,}375{,}000}{201 \times 16}} = 20.7$, say 21 in. $A_s = 0.0115 \times 16 \times 21 = 3.86$ in.

With this arrangement the depth may be reduced three inches but the tensile reinforcement must be increased about twenty per cent.

Material Quantities

Concrete:	Slab	= 18 × 24 × 0.292	= 126.1	cu. ft.
	Beams	= 3 × 1.01 × 16.67	= 50.6	cu. ft.
	Girder	= 2.50 × 22.67	= 56.7	cu. ft.
	Total		= 233.4	cu. ft. = *8.64 cu. yd.*

*6.92 is distance in feet between face of column and face of first intermediate beam and is the space in which stirrups are required.

Steel: Slabs $= 3 \times \frac{12}{2 \times 7} \times 16.67 \times 8.0 \times .376 = 129$ lb. (straight bars)

$3 \times \frac{12}{2 \times 7} \times 16.67 \times 12.0 \times .376 = 194$ lb. (bent bars)

$22.67 \times \frac{12}{15} \times 19.5 \times 3.75 = 133$ lb. (temp. bars)

456 lb.

Beams $= 3 \times 1 \times 18 \times 1.502 = 81$ lb. (straight bars)

$3 \times 2 \times 28 \times 1.502 = 252$ lb. (bent bars)

$3 \times 6 \times 3.58 \times 0.376 = 24$ lb. (stirrups)

357 lb.

Girder $= 2 \times 24 \times 1.502 = 72$ lb. (straight bars)

$3 \times 37.5 \times 1.502 = 169$ lb. (bent bars)

$1 \times 12 \times 2.044 = 25$ lb. (extra top bars)

$24 \times 5.42 \times 0.376 = 49$ lb. (stirrups)

315 lb.

Total Steel = 1128 lb.

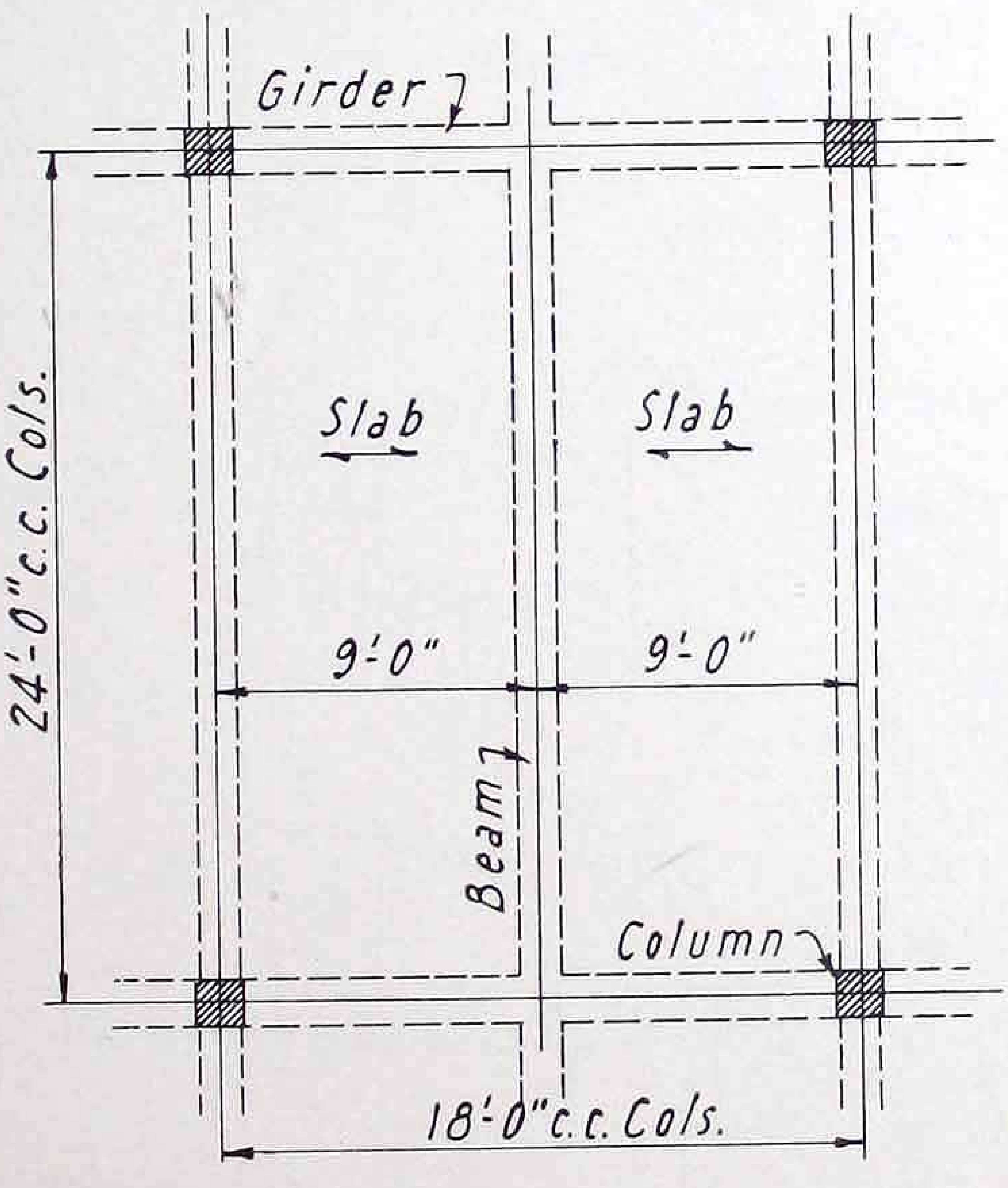


Fig. 7

Problem 2

Given the same panel as in the preceding example, except that framing is as shown in Figure 7.

Clear span of slab is approximately 8 ft.

Total superimposed load = 82 p.s.f.

From Table No. 7: *Use 3½-in. slab.* Weight = 44 p.s.f.

$$A_S = \frac{82 + 44}{117 + 44} \times 0.23 = 0.18 \text{ sq. in. } \Sigma o = \frac{504}{100 \times 7/8 \times 256} = 2.24$$

Use ⅜-in. rd. bars at 6-in. o.c.

Bend alternate bars over supporting beams.

Temperature bars same as Problem 1; ⅜-in. rd. bars at 15-in. o.c.

Design of Beams

Load = 9(82 + 44) = 1134 lb. per lin. ft.

Clear span = 22.67 ft., say 23 ft.

From Table No. 16: *Use 12-in. by 22-in. beam.* Web wt. = 232 lb. per lin. ft.

$$A_S = \frac{1134 + 232}{1150 + 232} \times 2.18 = 2.15 \text{ sq. in.}$$

Use five ¾-in. rd. bars, bend 3 bars in alternate beams and two bars in intermediate beams, thus providing five bars over all supports.

$$V = (9 \times 126 + 232)\,\frac{22.67}{2} = 15{,}500 \text{ lb.}$$

$$v = \frac{15{,}500}{12 \times 0.875 \times 20} = 74 \text{ p.s.i.}$$

$$v' = 74 - 40 = 34 \text{ p.s.i.}$$

$$a = \frac{22.67}{2} \times \frac{34}{74} = 5.20 \text{ ft.}$$

$v'b = 34 \times 12 = 408$

Use ⅜-in. rd. U-stirrups.

Spacing = 1 at 9; 1 at 12; 3 at 15 in. *10 required.*

$$\text{Check for bond } u = \frac{74 \times 12}{11.80} = 75 \text{ p.s.i.}$$

Design of Girders

$$\text{Concentrated load} = 2\left(\frac{24}{2}\left[9(82 + 44)\right] + \frac{22.67}{2} \times 232\right) = 32{,}460 \text{ lb.}$$

Assume uniform load (girder weight) = 270 lb. per lin. ft.

Clear span = 16.67 ft.

Assume b' = 14 in.

(1) $-M = 0.119 \times 32{,}460 \times 16.67 + \frac{1}{12} \times 270 \times 16.67^2 = 70{,}600$ ft. lb. = 847,000 in. lb.

$$\text{Required } d = \sqrt{\frac{847{,}000}{157 \times 14}} = \sqrt{385} = 19.6 \text{ (say 20 in.)}$$

Use 14-in. by 22-in. girder.

At the supports, $A_s = \dfrac{847{,}000}{20{,}000 \times 0.875 \times 20} = 2.43$ sq. in.

(2) $+M = 0.130 \times 32{,}460 \times 16.67 + \dfrac{1}{12} \times 270 \times 16.67^2 = 70{,}300 + 6{,}200 = 76{,}500$ ft. lb. $= 918{,}000$ in. lb.

$$A_s = \frac{918{,}000}{20{,}000 \times 0.875 \times 20} = 2.62 \text{ sq. in.}$$

Use $\begin{cases}\text{Three } \tfrac{3}{4}\text{-in. rd. bars, straight.}\\ \text{Two } \tfrac{7}{8}\text{-in. rd. bars, bent.}\end{cases}$

Maximum End Shear $= \dfrac{32{,}460}{2} + \dfrac{16.67}{2} \times 270 = 16{,}230 + 2250 = 18{,}480$ lb.

$$v = \frac{18{,}480}{14 \times 0.875 \times 20} = 75 \text{ p.s.i.} \qquad v' = 35 \text{ p.s.i.}$$

$v'b = 35 \times 14 = 490$

Shear at center $= 16{,}230$ lb.

$$v = \frac{16{,}230}{14 \times 0.875 \times 20} = 66 \text{ p.s.i.} \qquad v' = 26 \text{ p.s.i.}$$

$v'b = 26 \times 14 = 364$

Use $\tfrac{3}{8}$*-in. rd. U-stirrups.* Maximum spacing $= 0.75 \times 20 = 15.0$ in. Spacing = 3 at 6, 9 at 9-in. *24 stirrups required.*

Bond at support, $u = \dfrac{75 \times 14}{4 \times 2.75} = 96$ p.s.i.

Material Quantities

Concrete: Slab $= 18 \times 24 \times 0.292 = 126.1$ cu. ft.
Beams $= 2 \times 1.54 \times 22.67 = 69.8$ cu. ft.
Girder $= 1.80 \times 16.67 = 30.0$ cu. ft.
225.9 cu. ft. $=$ *8.35 cu. yd.*

Steel: Slabs $= 2 \times \left(\dfrac{12}{2 \times 6}\right) \times 22.67 \times 9.0 \times 0.376 = 153$ lb. (straight bars)

$2 \times \left(\dfrac{12}{2 \times 6}\right) \times 22.67 \times 13.5 \times 0.376 = 230$ lb. (bent bars)

$16.67 \times \dfrac{12}{15} \times 25.5 \times 0.376 = 128$ lb. (temp. bars)

511 lb.

Beams	$= 2 \times 2 \times 24 \times 1.502 =$	144 lb.	(straight bars)
	$2 \times 2\frac{1}{2} \times 37.25 \times 1.502 =$	280 lb.	(bent bars)
	$2 \times 10 \times 4.58 \times 0.376 =$	34 lb.	(stirrups)
		458 lb.	
Girder	$= 3 \times 18 \times 1.502 =$	81 lb.	(straight bars)
	$2 \times 28.25 \times 2.044 =$	116 lb.	(bent bars)
	$24 \times 4.75 \times 0.376 =$	44 lb.	(stirrups)
		241 lb.	
	Total steel =	*1210 lb.*	

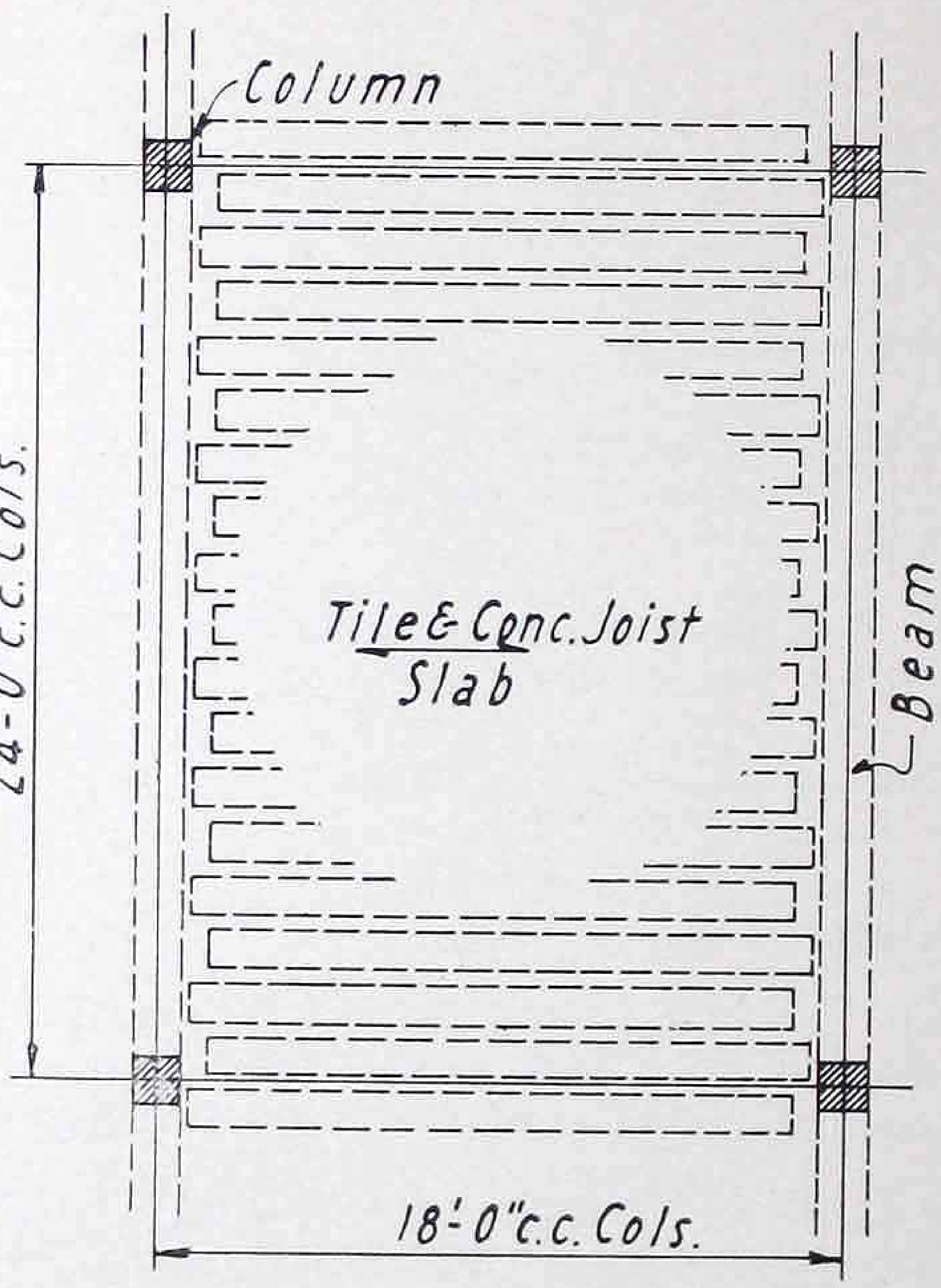


Fig. 8

Problem 3

Given the same panel as in Problem 1, but framed as shown in Fig. 8. Design the panel, using one-way tile and concrete joist slab. Assume that beams are 16 in. wide. The clear span will be 16.67 ft., say 17 ft. The superimposed load is 82 p.s.f.

From Table No. 8, *Use 6-in. tile and 3-in. topping, 6-in. joists — 18-in. o.c.* The weight of this slab is 77 p.s.f.

$$\text{Required } A_S = \frac{\text{Total Weight}}{\text{Load Coefficient}} \times \text{Steel Coefficient for } \frac{wl^2}{12}$$

$$= \frac{82 + 77}{332} \times 1.05 = 0.50 \text{ sq. in. per joist}$$

Use $\left\{\begin{array}{l}\text{One } \tfrac{1}{2}\text{-in. sq. bar, straight} \\ \text{One } \tfrac{1}{2}\text{-in. sq. bar, bent}\end{array}\right\}$ per joist.

Bond at support: $u = \dfrac{1980}{4 \times \tfrac{7}{8} \times 8} = 71$ p.s.i.

Transverse reinforcement: $A_S = 0.002 \times 3 \times 12 = 0.07$ sq. in.

Use ⅜-in. rd. bars at 15-in. o.c. *13 required.*

Stagger tile joints in adjacent rows of tile as shown.

Design of Beams

Load: $18(82 + 77) = 2860$ lb. per lin. ft.

Clear span: 22.67 ft. assuming 16-in. column.

From Table 16: *Use 16-in. by 30-in. beam.*

$$\text{Web wt.} = \frac{16 \times 21}{144} \times 150 + 2(112 - 77) = 408 \text{ lb. per ft.}$$

$$A_S = \frac{2860 + 408}{3230 + 408} \times 4.08 = 3.67 \text{ sq. in.}$$

Use $\left\{\begin{array}{l}\text{Three } \tfrac{7}{8}\text{-in. rd. bars, straight} \\ \text{Three } \tfrac{7}{8}\text{-in. rd. bars, bent}\end{array}\right\}$ $A_S = 3.60$ sq. in.

$V\ (2860 + 408) \times \dfrac{22.67}{2} = 36{,}900 \qquad v = \dfrac{36{,}900}{16 \times 0.875 \times 28} = 94$ p.s.i.

$v' = 94 - 40 = 54$ p.s.i. $\qquad v'b = 54 \times 16 = 865$

$a = \dfrac{54}{94} \times \dfrac{22.67}{2} = 6.50 \qquad$ Max. spacing $= 0.75 \times 28 = 21$ in.

Use ⅜-in. rd. U-stirrups. Spacing: 2 at 3, 4 at 6, 2 at 9, 2 at 12 in.
20 required.

Bond at support: $u = \dfrac{94 \times 16}{6 \times 2.75} = 92$ p.s.i.

Material Quantities

Tile $16 \times 16 =$ *256 units of 6-in. Tile.*

Concrete

Slab $\dfrac{18 \times 24 \times 9}{12} - \dfrac{256 \times 6}{12} = 196.0$ cu. ft.

Beam $\dfrac{16 \times 21}{144} \times 22.67 = 52.9$ cu. ft.

248.9 cu. ft. = 9.23 cu. yd.

Steel

Slab	$16 \times 18 \times 0.850$	= 245 lb.	(straight)
	$16 \times 27.5 \times 0.850$	= 374 lb.	(bent)
	$13 \times 25.5 \times 0.376$	= 124 lb.	(temperature)
		743 lb.	
Beam	$3 \times 24 \times 2.044$	= 148 lb.	(straight)
	$3 \times 37.8 \times 2.044$	= 232 lb.	(bent)
	$20 \times 6.08 \times 0.376$	= 45 lb.	(stirrups)
		425 lb.	

Total Steel 1168 lb.

Problem 4

Given the same panel as in Problem 1, framed as shown in Fig. 9. Design panel, using one-way tile and concrete joist slab.

The clear span of the slab, assuming 12-in. width of beams, is 11.0 ft. The superimposed load is 82 p.s.f.

From Table No. 8: *Use 4-in. tile + 2-in. topping, 5-in. joists, 17 in. o.c.* Weight of slab = 51 p.s.f.

$$A_S = \frac{133}{309} \times 0.62 = 0.27 \text{ sq. in. per joist}$$

Use $\left\{\begin{array}{l}\text{One } 3/8\text{-in. rd. bar, straight} \\ \text{One } 1/2\text{-in. rd. bar, bent}\end{array}\right\}$ per joist.

$$\text{Bond at support: } u = \frac{1040}{3.14 \times 7/8 \times 5} = 76 \text{ p.s.i.}$$

Transverse or temperature reinforcement: $A_S = 0.0025 \times 2.0 \times 12 =$ 0.06 sq. in. *Use 1/4-in. rd. bars at 10 in. o.c. 26 required.*

Stagger tile joints as shown in Fig. 9.

Design of Beams

Load: $12 \times (82 + 51) = 1600$ lb. per lin. ft. Assuming a 16-in. width of girder, the clear span of the beam is 16.67 ft., say 17 ft. From Table No. 16: *Use 12-in. by 20-in. beam.*

$$\text{Web wt.} = \frac{12 \times 14}{144} \times 150 + 2(75 - 51) = 223 \text{ lb. per lin. ft.}$$

$$A_S = \frac{1600 + 223}{1860 + 223} \times 1.97 = 1.73 \text{ sq. in.}$$

Use four 3/4-in. rd. bars, bend two. $A_S = 1.76$ sq. in.

$$V = (1600+223) \times \frac{16.67}{2} = 15{,}200 \text{ lb.} \qquad v = \frac{15{,}200}{12 \times 0.875 \times 18} = 81 \text{ p.s.i.}$$

$$v' = 81 - 40 = 41 \text{ p.s.i.} \qquad v'b = 41 \times 12 = 492$$

$$a = \frac{41}{81} \times \frac{16.67}{2} = 4.23 \text{ ft.} \qquad \text{Max. spacing} = 0.75 \times 18 = 13.5 \text{ in.}$$

Use 3/8-in. rd. U-stirrups, Spacing = 9, 12, 12, 12, *8 required per beam.*

Bond at support: $u = \dfrac{81 \times 12}{4 \times 2.36} = 103$ p.s.i. (Sufficiently close to allowable maximum)

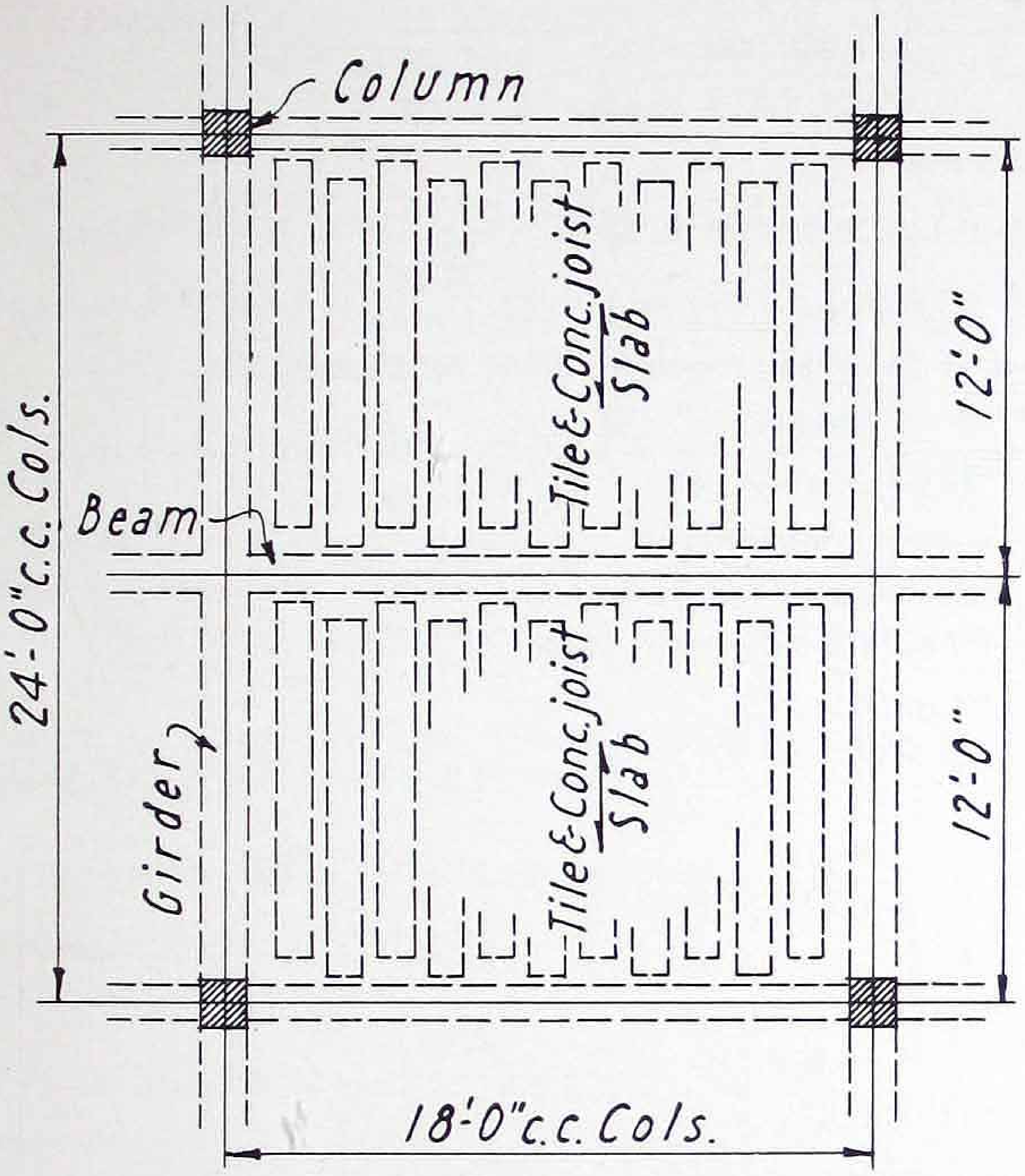


Fig. 9

Design of Girder

Concentrated load: $P = 2\left(\frac{18}{2}\left[12\,(82 + 51)\right] + \frac{16.67}{2} \times 223\right) =$ 32,500 lb.

Assumed girder weight: 350 lb. per lin. ft.

Clear span: 22.67 ft.

The coefficients of wl^2 and Pl for moment are obtained from Table No. 1 and Fig. 1.

At support: $-M = 0.119 \times 32{,}500 \times 22.67 + \frac{1}{12} \times 350 \times 22.67^2$

$= 87{,}800 + 15{,}000 = 102{,}800$ ft. lb. $= 1{,}230{,}000$ in. lb.

Assume $b' = 14$ in.

$$d = \sqrt{\frac{1{,}230{,}000}{157 \times 14}} = 23.6, \text{ say } 24 \text{ in.}$$

Use 14-in. by 26-in. girder.

$$A_S = \frac{1{,}230{,}000}{20{,}000 \times 0.875 \times 24} = 2.93 \text{ sq. in.}$$

At the center:

$$+M = 0.130 \times 32{,}500 \times 22.67 + \frac{1}{12} \times 350 \times 22.67^2$$

$$= 95{,}800 + 15{,}000 = 110{,}800 \text{ ft. lb.} = 1{,}330{,}000 \text{ in. lb.}$$

Using $d = 24$ in. the required flange width is:

$$b = \frac{1{,}330{,}000}{131.3 \times 24 \times 24} = 17.6 \text{ in. Actual width is 34 in.}$$

$$A_S = \frac{1{,}330{,}000}{20{,}000 \times 0.875 \times 24} = 3.16 \text{ sq. in.}$$

Use four 1-in. rd. bars, bend two.

Shear at support:

$$V = \frac{32{,}500}{2} + \frac{22.67 \times 350}{2} = 20{,}210 \text{ lb.}$$

$$v = \frac{20{,}210}{14 \times 0.875 \times 24} = 69 \text{ p.s.i.} \qquad v' = 69 - 40 = 29 \text{ p.s.i.}$$

$$v'b = 416$$

Shear at center:

$$V = \frac{16{,}250}{14 \times 0.875 \times 24} = 55 \text{ p.s.i.} \qquad v' = 15 \text{ p.s.i.} \qquad v'b = 210$$

Maximum stirrup spacing: $\frac{3}{4} \times 24 = 18$ in.

Use $\frac{3}{8}$-in. rd. U-stirrups. Spacing 5 at 9, 4 at 12, 2 at 15-in. *22 required.*

Bond at end: $u = \dfrac{69 \times 14}{4 \times 3.14} = 77$ p.s.i.

Material Quantities

Tile $2 \times 11 \times 10$ = *220 units of 4-in. Tile.*

Concrete Slab: $(18 \times 24)\dfrac{6}{12} - 220 \times \dfrac{4}{12} = 142.7$ cu. ft.

Beams: $2 \times 1.17 \times 16.83$ = 39.5 cu. ft.

Girder: 1.94×22.67 = 44.0 cu. ft.

226.2 cu. ft. = 8.40 cu. yd.

Steel	Slab:	$2 \times 10 \times 12 \times 0.376$	$= 90$ lb.	(straight)
		$2 \times 10 \times 18.3 \times 0.668$	$= 244$ lb.	(bent)
		$26 \times 19 \times 0.168$	$= 83$ lb.	(temperature)
			417 lb.	
	Beams:	$2 \times 2 \times 18 \times 1.502$	$= 108$ lb.	(straight)
		$2 \times 2 \times 28.1 \times 1.502$	$= 169$ lb.	(bent)
		$2 \times 8 \times 4.1 \times 0.376$	$= 25$ lb.	(stirrups)
			302 lb.	
	Girder:	$2 \times 24 \times 2.670$	$= 128$ lb.	(straight)
		$2 \times 37.6 \times 2.670$	$= 200$ lb.	(bent)
		$22 \times 5.42 \times 0.376$	$= 45$ lb.	(stirrups)
			373 lb.	
		Total Steel	*= 1092 lb.*	

Problem 5

Given the same panel as in Problem 1, framed as shown in Fig. 10. Design panel using 20-in. metal pans and concrete joists. Use tapered pans. The clear span is approximately 17 ft., the superimposed load is 82 p.s.f.

From Table No. 10 *use 6-in. pans + 2-in. topping, 6-in. joists — 26-in. o.c.* Weight of slab is 48 p.s.f.

$$A_S = \frac{82 + 48}{244} \times 1.27 = 0.68 \text{ sq. in. per joist.}$$

Use $\left\{\begin{array}{l}\text{One } \tfrac{5}{8}\text{-in. rd. bar, straight} \\ \text{One } \tfrac{3}{4}\text{-in. rd. bar, bent}\end{array}\right\}$ per joist.

$$\text{Bond at support: } u = \frac{2370}{4.72 \times \tfrac{7}{8} \times 6.88} = 83 \text{ p.s.i.}$$

Transverse reinforcement: The A. C. I. Code requires an area of at least 0.049 sq. in. per ft. width for floors carrying a live load not in excess of 50 p.s.f. *Use ¼-in. rd. bars at 12-in. o.c. 17 required.*

Design of Beams

Load: $18(82 + 48) = 2{,}340$ lb. per lin. ft. The clear span is 22.67 ft., say 23 ft.

From Table No. 16, *Use 14-in. by 28-in. beam.*

$$\text{Beam Weight: } \frac{14 \times 20}{144} \times 150 + 2(100 - 48) = 396 \text{ lb. per ft.}$$

$$A_S = \frac{2340 + 396}{2400 + 396} \times 3.31 = 3.23 \text{ sq. in.}$$

Use $\left\{\begin{array}{l}\text{Two 1-in. rd. bars, straight.} \\ \text{Three } \tfrac{7}{8}\text{-in. rd. bars, bent.}\end{array}\right.$

$$V = (2340 + 396) \times \frac{22.67}{2} = 31{,}000 \text{ lb.}$$

$$v = \frac{31{,}000}{14 \times 0.875 \times 26} = 97 \text{ p.s.i.}$$

$$v' = 97 - 40 = 57 \text{ p.s.i.} \qquad v'b = 57 \times 14 = 798$$

$$a = \frac{57}{97} \times \frac{22.67}{2} = 6.70 \text{ ft.}$$

Use 3/8-in. rd. U-stirrups. Maximum spacing = 19.5 in.

Spacing = 3, 5 at 6, 3 at 9, 1 at 15. *20 required.*

Bond at support: $u = \dfrac{97 \times 14}{6 \times 2.75} = 82$ p.s.i.

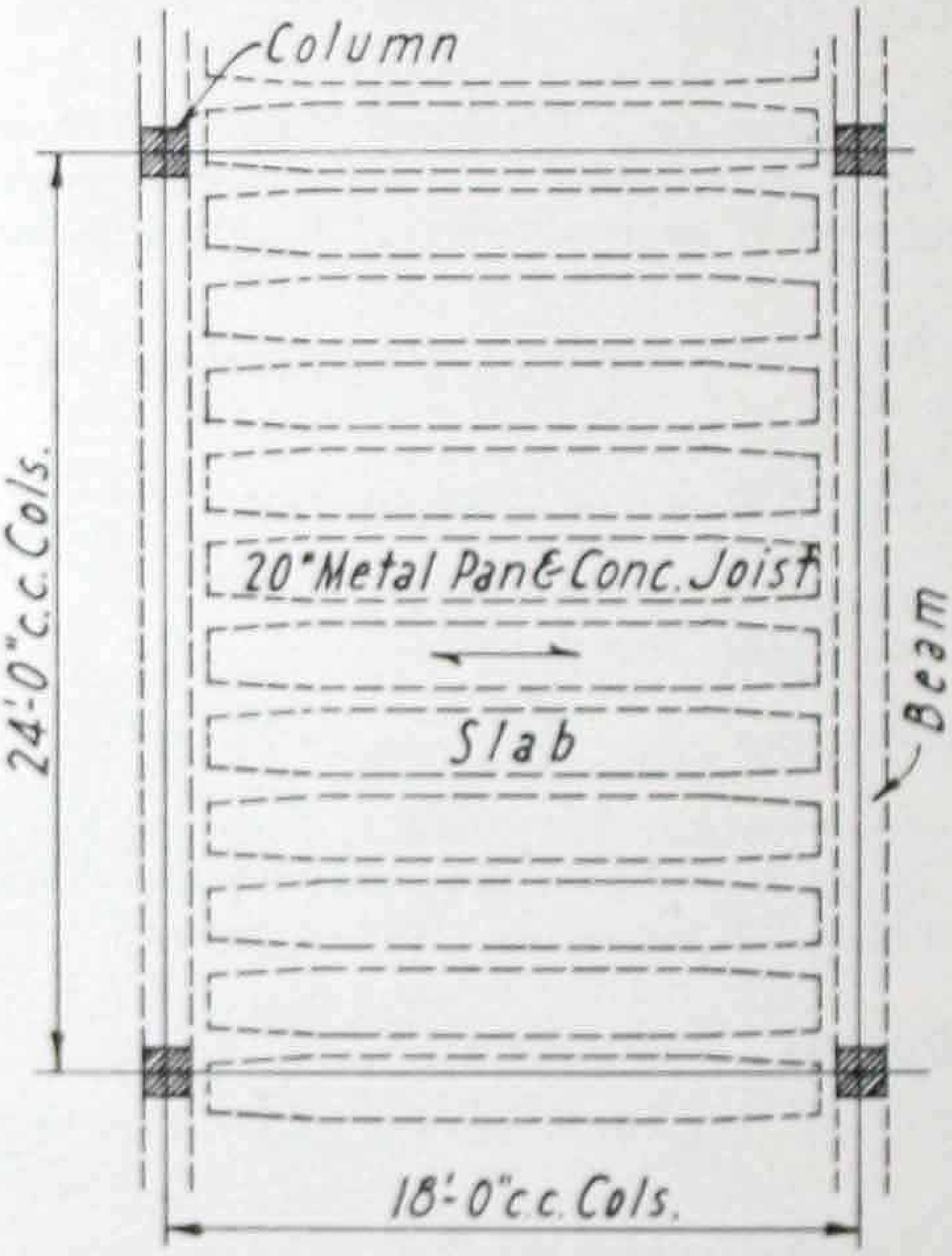


Fig. 10

Material Quantities

Concrete

Slab: $18 \times 24 \times \frac{8}{12} - \frac{12 \times 24}{26} \times \frac{6}{144}(10 \times 19.5 + 6 \times 17.5) =$ 150.0 cu. ft.

Beam: $1.94 \times 22.67 = \underline{44.2}$ cu. ft.

194.2 cu. ft. = *7.20 cu. yd.*

Steel

Slab: $\frac{12 \times 24}{26} \times 18 \times 1.043 = 208$ lb. (straight)

$\frac{12 \times 24}{26} \times 27.5 \times 1.502 = 458$ lb. (bent)

$17 \times 25.0 \times 0.167 = \underline{71}$ lb. (transverse)

737 lb.

Beam: $2 \times 24 \times 2.670 = 128$ lb. (straight)

$3 \times 37.7 \times 2.044 = 231$ lb. (bent)

$20 \times 5.75 \times 0.376 = \underline{43}$ lb. (stirrups)

402 lb.

Total Steel = 1139 lb.

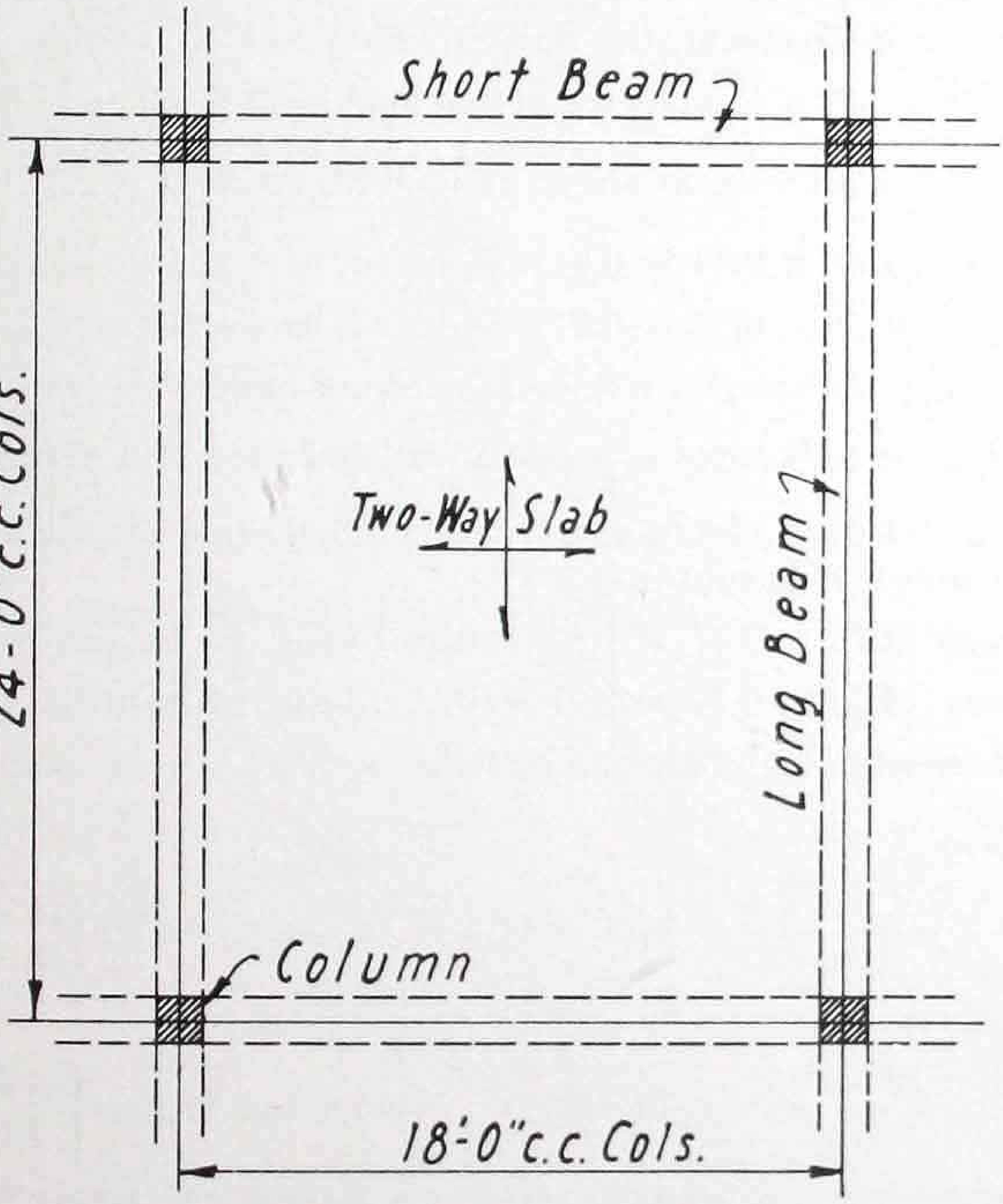


Fig. 11

*Problem 6**

Given an interior panel, 18 ft. by 24 ft. between centerlines of beams as in Fig. 11, and a total superimposed load of 82 p.s.f. Determine size of slab and beams, amount of reinforcement, and quantities of materials required.

Design of Slab

Assuming beam widths equal to 1 ft., the ratio of long to short clear spans is $\frac{24 - 1}{18 - 1} = 1.35$. For design of slab, use Table No. 19 (Ratio 1.4 to 1.0). In column headed *23.8 × 17* and for *Interior-Interior* condition of continuity, a 5½-in. slab supporting 128 p.s.f. is seen to be sufficient. The 5½-in. slab weighs 69 p.s.f.

Reinforcement given in table is:

Short way: ½-in. rd. bars at 5½-in. o.c. (area per linear foot = 0.44)

Long way: ½-in. rd. bars at 9-in. o.c. (area per linear foot = 0.27)

With this reinforcement, the slab can carry

$128 + 69 = 197$ p.s.f.; but the actual load is $82 + 69 = 151$ p.s.f.

Reduce the reinforcement above by multiplying it by $\frac{151}{197} = 0.77$:

Short way ($0.77 \times 0.44 = 0.34$): ½-in. rd. bars at 7-in. o.c.

Long way ($0.77 \times 0.27 = 0.21$): ½-in. rd. bars at 12-in. o.c.

This is the reinforcement required for center bands. The width of outer bands, adjacent to beams, is $\frac{17}{4} = 4.25$ ft., and the width of center bands is $23.0 - 2 \times 4.25 = 14.5$ ft. and $17.0 - 2 \times 4.25 = 8.5$ ft. Reinforcement in outer bands is reduced to:

Short way ($0.75 \times 0.77 \times 0.44 = 0.26$): ½-in. rd. bars at 9-in. o.c.

Long way ($0.75 \times 0.77 \times 0.27 = 0.16$): ½-in. rd. bars at 14-in.** o.c.

Total number of slab bars in a panel is:

Short way:

$$\frac{12 \times 14.5}{7} + \frac{12 \times 8.5}{9} = 24.9 + 11.3 = 36.2, \text{ say 36 bars} \begin{cases} \text{18 straight.} \\ \text{18 bent.} \end{cases}$$

Long way:

$$\frac{12 \times 8.5}{12} + \frac{12 \times 8.5}{14} = 8.5 + 7.3 = 15.8, \text{ say 15 bars} \begin{cases} \text{8 straight.} \\ \text{7 bent.} \end{cases}$$

*Explanation and discussion pertaining to two-way concrete slabs are given on Pages 45 to 49.

**14 in. is maximum spacing allowed. See explanation of Tables No. 17-22, on Pages 45 to 49.

Design of Beams

Use beam load coefficients, $(1 - er)$ and $(1 - r)$ in Table No. 19 for *Interior-Interior* condition of continuity in the bottom lines: for bending, 0.835 (long beams), 0.440 (short beams); for shear, 0.733 (long beams), 0.267 (short beams). Column widths are taken as 16 in.

Short Beam

Clear span: $18.00 - 1.33 = 16.67$ ft. Use Table No. 16, $l = 17$ ft.

Superimposed load for bending:

$$2 \times \frac{24}{2} \times 0.440 \times 151 = 1590 \text{ lb. per lin. ft.}$$

Use beam 12 × 20 in. Weight of web: $250 - 69 = 181$, say 180 lb.

$$\text{From Table No. 16: } A_S = \frac{1590 + 180}{1860 + 180} \times 1.97 = 1.71 \text{ sq. in.}$$

Use $\begin{cases}\text{Two } \frac{3}{4}\text{-in. rd. bars, straight.}\\ \text{Two } \frac{3}{4}\text{-in. rd. bars, bent.}\end{cases}$

Superimposed load for shear:

$$2 \times \frac{24}{2} \times 0.267 \times 151 = 970 \text{ lb. per lin. ft.}$$

$$V = (970 + 180) \times \frac{16.67}{2} = 9{,}600 \text{ lb.}$$

$$v = \frac{9{,}600}{12 \times 0.875 \times 18} = 51 \text{ p.s.i.}$$

$$v' = 51 - 40 = 11 \text{ p.s.i.}$$

$$v'b = 11 \times 12 = 132$$

$$a = \frac{11}{51} \times \frac{16.67}{2} = 1.8 \text{ ft. Maximum spacing} = 0.75 \times 18 = 13.5 \text{ in.}$$

Use ⅜-in. rd. U-stirrups. Spacing = 2 at 12 in. *4 required.*

$$\text{Bond at support: } u = 51 \times \frac{12}{4 \times 2.36} = 65 \text{ p.s.i.}$$

Long Beam

Clear Span: $24.00 - 1.33 = 22.67$ ft. Use Table No. 16, $l = 23$ ft.

Superimposed load for bending:

$$2 \times \frac{18}{2} \times 0.835 \times 151 = 2270 \text{ lb. per lin. ft.}$$

Use beam 14 × 28 in. Weight of web: $408 - 69 = 339$, say, 340 lb.

$$\text{From Table No. 16: } A_S = \frac{2270 + 340}{2400 + 340} \times 3.31 = 3.15 \text{ sq. in.}$$

Use $\begin{cases}\text{Two 1-in. rd. bars, straight.}\\ \text{Two 1-in. rd. bars, bent.}\end{cases}$

Superimposed load for shear:

$$2 \times \frac{18}{2} \times 0.733 \times 151 = 1990 \text{ lb. per lin. ft.}$$

$$V = (1990 + 340) \times \frac{22.67}{2} = 26{,}400 \text{ lb.}$$

$$v = \frac{26{,}400}{14 \times 0.875 \times 26} = 83 \text{ p.s.i.}$$

$$v' = 83 - 40 = 43 \text{ p.s.i.}$$

$$v'b = 43 \times 14 = 600$$

$$a = \frac{43}{83} \times \frac{22.67}{2} = 5.87. \text{ Maximum spacing} = 0.75 \times 26 = 19.5 \text{ in.}$$

Use 3/8-in. rd. U-stirrups. Spacing 2 at 6, 2 at 9, 12, 15, 18 in. *14 required.*

$$\text{Bond at support: } u = 83 \times \frac{14}{4 \times 3.14} = 93$$

Material Quantities

Concrete

Slab:	18 × 24 × 0.458	= 198.0 cu. ft.
Beams:	1.21 × 16.83	= 20.4 cu. ft.
	2.19 × 24.00	= 52.6 cu. ft.
		271.0 cu. ft. = *10.03 cu. yd.*

Steel

Slab:	18 × 18.0 × 0.668	= 217 lb. (straight)
	18 × 27.3 × 0.668	= 329 lb. (bent)
	8 × 24.0 × 0.668	= 128 lb. (straight)
	7 × 36.3 × 0.668	= 170 lb. (bent)
Beams:	2 × 18.0 × 1.502	= 54 lb. (straight)
	2 × 28.1 × 1.502	= 84 lb. (bent)
	4 × 4.08 × 0.376	= 6 lb. (stirrups)
	2 × 24.0 × 2.670	= 128 lb. (straight)
	2 × 37.7 × 2.670	= 201 lb. (bent)
	14 × 5.58 × 0.376	= 29 lb. (stirrups)
	Total	= *1346 lb.*

Summary

A brief outline of design procedures has been presented in Problems 1 to 6 for various systems of concrete floor slabs. The problems also give quantities of material which are helpful in making comparisons prior to adopting the system best suited to a given set of conditions.

From the summary in Table No. 2, it is evident that for the fairly long spans used, and a light load, other things being equal, the ribbed floor with metal pans requires the least concrete, only slightly more reinforce-

TABLE No. 2—SUMMARY OF QUANTITIES

Problem No.	Type of Slab	Material Quantities		
		Concrete Cu. Yd.	Reinforcement Lb.	Filler Blocks No. and Size
1	One-way Solid Slab (1)	8.64	1128	......
2	One-way Solid Slab (2)	8.35	1210	......
3	One-way Tile Filler Ribbed Slab (1)	9.23	1168	256 of 6"
4	One-way Tile Filler Ribbed Slab (2)	8.40	1092	220 of 4"
5	One-way Metal Pan Filler Ribbed Slab	7.20	1139	......
6	Two-way Solid Slab	10.03	1346	......

ment than the type requiring the least steel and is the lightest construction because of the smaller quantity of concrete. This type of floor will in general prove most economical for the case considered. It can also be seen that the two-way solid slab is not well suited for this case. Had the superimposed load been much heavier, this type would be relatively more economical. A complete cost estimate must, of course, include the cost of forms.

SECTION III—STRUCTURAL DESIGN TABLES

TABLE No. 3—VALUES OF DESIGN CONSTANTS FOR VARIOUS COMBINATIONS OF STEEL AND CONCRETE STRESSES

f_s	16,000								
n	15					12		10	
f_c	650	700	750	800	900	1000	1125	1200	1350
p	0.0077	0.0087	0.0097	0.0107	0.0129	0.0134	0.0161	0.0161	0.0193
k	0.3786	0.3962	0.4128	0.4286	0.4576	0.4286	0.4576	0.4286	0.4576
j	0.8738	0.8679	0.8624	0.8571	0.8475	0.8571	0.8475	0.8571	0.8475
K	107.5	120.4	133.5	146.9	174.5	183.7	218.1	220.4	261.8
f_s	18,000								
n	15					12		10	
f_c	650	700	750	800	900	1000	1125	1200	1350
p	0.0063	0.0072	0.0080	0.0089	0.0107	0.0111	0.0134	0.0133	0.0161
k	0.3514	0.3684	0.3846	0.4000	0.4288	0.4000	0.4286	0.4000	0.4286
j	0.8829	0.8772	0.8718	0.8667	0.8571	0.8667	0.8571	0.8667	0.8571
K	100.8	113.1	125.7	138.7	165.4	173.3	206.6	208.0	247.9
f_s	20,000								
n	15					12		10	
f_c	650	700	750	800	900	1000	1125	1200	1350
p	0.0053	0.0060	0.0068	0.0075	0.0091	0.0094	0.0113	0.0112	0.0136
k	0.3277	0.3443	0.3600	0.3750	0.4030	0.3750	0.4030	0.3750	0.4030
j	0.8908	0.8852	0.8800	0.8750	0.8657	0.8750	0.8657	0.8750	0.8657
K	94.87	106.7	118.8	131.3	157.0	164.1	196.2	196.9	235.5

TABLE No. 4—RECTANGULAR BEAMS WITH COMPRESSIVE REINFORCEMENT DESIGN VALUES OF p AND K FOR

$$f_s = 20{,}000, f_c = 900, n = 15$$

p'	$d'/d = 0.02$		$d'/d = 0.04$		$d'/d = 0.06$		$d'/d = 0.08$		$d'/d = 0.10$	
	p	K	p	K	p	K	p	K	p	K
0.002 . . .	0.0103	180	0.0102	179	0.0102	177	0.0101	176	0.0100	174
0.004 . . .	0.0115	204	0.0114	200	0.0112	197	0.0111	194	0.0110	191
0.006 . . .	0.0127	227	0.0125	222	0.0123	218	0.0121	213	0.0119	208
0.008 . . .	0.0139	251	0.0136	244	0.0134	238	0.0131	231	0.0129	225
0.010 . . .	0.0151	274	0.0148	266	0.0145	258	0.0141	250	0.0138	242
0.012 . . .	0.0163	298	0.0159	288	0.0155	278	0.0151	268	0.0148	259
0.014 . . .	0.0175	321	0.0170	310	0.0166	298	0.0161	287	0.0157	276
0.016 . . .	0.0187	345	0.0181	331	0.0177	319	0.0172	306	0.0167	293
0.018 . . .	0.0199	368	0.0193	353	0.0188	339	0.0182	324	0.0176	310
0.020 . . .	0.0211	392	0.0204	375	0.0198	359	0.0192	343	0.0186	328

p'	$d'/d = 0.12$		$d'/d = 0.14$		$d'/d = 0.16$		$d'/d = 0.18$		$d'/d = 0.20$	
	p	K	p	K	p	K	p	K	p	K
0.002 . . .	0.0100	173	0.0099	171	0.0099	170	0.0098	168	0.0097	167
0.004 . . .	0.0109	188	0.0107	185	0.0106	182	0.0105	180	0.0104	177
0.006 . . .	0.0117	204	0.0116	199	0.0114	195	0.0112	191	0.0110	187
0.008 . . .	0.0126	219	0.0124	214	0.0121	208	0.0119	203	0.0116	198
0.010 . . .	0.0135	235	0.0132	228	0.0129	221	0.0126	214	0.0123	208
0.012 . . .	0.0144	250	0.0140	242	0.0136	234	0.0133	226	0.0129	218
0.014 . . .	0.0153	266	0.0148	256	0.0144	246	0.0140	237	0.0135	228
0.016 . . .	0.0161	282	0.0157	270	0.0152	259	0.0147	249	0.0142	238
0.018 . . .	0.0170	297	0.0165	284	0.0159	272	0.0154	260	0.0148	248
0.020 . . .	0.0179	313	0.0173	298	0.0167	285	0.0161	271	0.0154	259

TABLE No. 5—SECTIONAL AREA IN SQ. IN. OF VARIOUS NUMBERS OF BARS

Number of Bars	3/8"φ	1/2"φ	1/2"□	5/8"φ	3/4"φ	7/8"φ	1"φ	1"□	1 1/8"□	1 1/4"□
Wt. per Ft.	0.376	0.668	0.850	1.043	1.502	2.044	2.670	3.400	4.303	5.313
Perimeter .	1.18	1.57	2.00	1.96	2.36	2.75	3.14	4.00	4.50	5.00
1	0.11	0.20	0.25	0.31	0.44	0.60	0.79	1.00	1.27	1.56
2	0.22	0.40	0.50	0.62	0.88	1.20	1.58	2.00	2.54	3.12
3	0.33	0.60	0.75	0.93	1.32	1.80	2.37	3.00	3.81	4.68
4	0.44	0.80	1.00	1.24	1.76	2.40	3.16	4.00	5.08	6.24
5	0.55	1.00	1.25	1.55	2.20	3.00	3.95	5.00	6.35	7.80
6	0.66	1.20	1.50	1.86	2.64	3.60	4.74	6.00	7.62	9.36
7	0.77	1.40	1.75	2.17	3.08	4.20	5.53	7.00	8.89	10.92
8	0.88	1.60	2.00	2.48	3.52	4.80	6.32	8.00	10.16	12.48
9	0.99	1.80	2.25	2.79	3.96	5.40	7.11	9.00	11.43	14.04
10	1.10	2.00	2.50	3.10	4.40	6.00	7.90	10.00	12.70	15.60
11	1.21	2.20	2.75	3.41	4.84	6.60	8.69	11.00	13.97	17.16
12	1.32	2.40	3.00	3.72	5.28	7.20	9.48	12.00	15.24	18.72
13	1.43	2.60	3.25	4.03	5.72	7.80	10.27	13.00	16.51	20.28
14	1.54	2.80	3.50	4.34	6.16	8.40	11.06	14.00	17.78	21.84
15	1.65	3.00	3.75	4.65	6.60	9.00	11.85	15.00	19.05	23.40

TABLE No. 6—AREA OF STEEL IN SQ. IN. PER LINEAR FOOT OF SLAB FOR RODS SPACED AT VARIOUS INTERVALS

Spacing c. to c. in Inches	⅜"φ	½"φ	½"□	⅝"φ	¾"φ	⅞"φ	1"φ	1"□	1⅛"□	1¼"□
3	0.44	0.80	1.00	1.24	1.76	2.40	3.16	4.00	5.08	
3½	0.38	0.69	0.86	1.06	1.51	2.06	2.71	3.43	4.35	5.35
4	0.33	0.60	0.75	0.93	1.32	1.80	2.37	3.00	3.81	4.68
4½	0.29	0.53	0.67	0.83	1.17	1.60	2.11	2.67	3.39	4.16
5	0.26	0.48	0.60	0.74	1.06	1.44	1.90	2.40	3.05	3.74
5½	0.24	0.44	0.55	0.68	0.96	1.31	1.72	2.18	2.77	3.40
6	0.22	0.40	0.50	0.62	0.88	1.20	1.58	2.00	2.54	3.12
6½	0.20	0.37	0.46	0.57	0.81	1.11	1.46	1.85	2.34	2.88
7	0.19	0.34	0.43	0.53	0.75	1.03	1.35	1.71	2.18	2.67
7½	0.18	0.32	0.40	0.50	0.70	0.96	1.26	1.60	2.03	2.50
8	0.16	0.30	0.37	0.46	0.66	0.90	1.18	1.50	1.90	2.34
8½	0.15	0.28	0.35	0.44	0.62	0.85	1.12	1.41	1.79	2.20
9		0.27	0.33	0.41	0.59	0.80	1.05	1.33	1.69	2.08
9½		0.25	0.32	0.39	0.56	0.76	1.00	1.26	1.60	1.97
10		0.24	0.30	0.37	0.53	0.72	0.95	1.20	1.52	1.87

EXPLANATION OF TABLE No. 7

To determine the depth of slab for a given superimposed load, clear span and "condition of continuity," read down the column for the given clear span and across from the given "condition of continuity" until a safe load

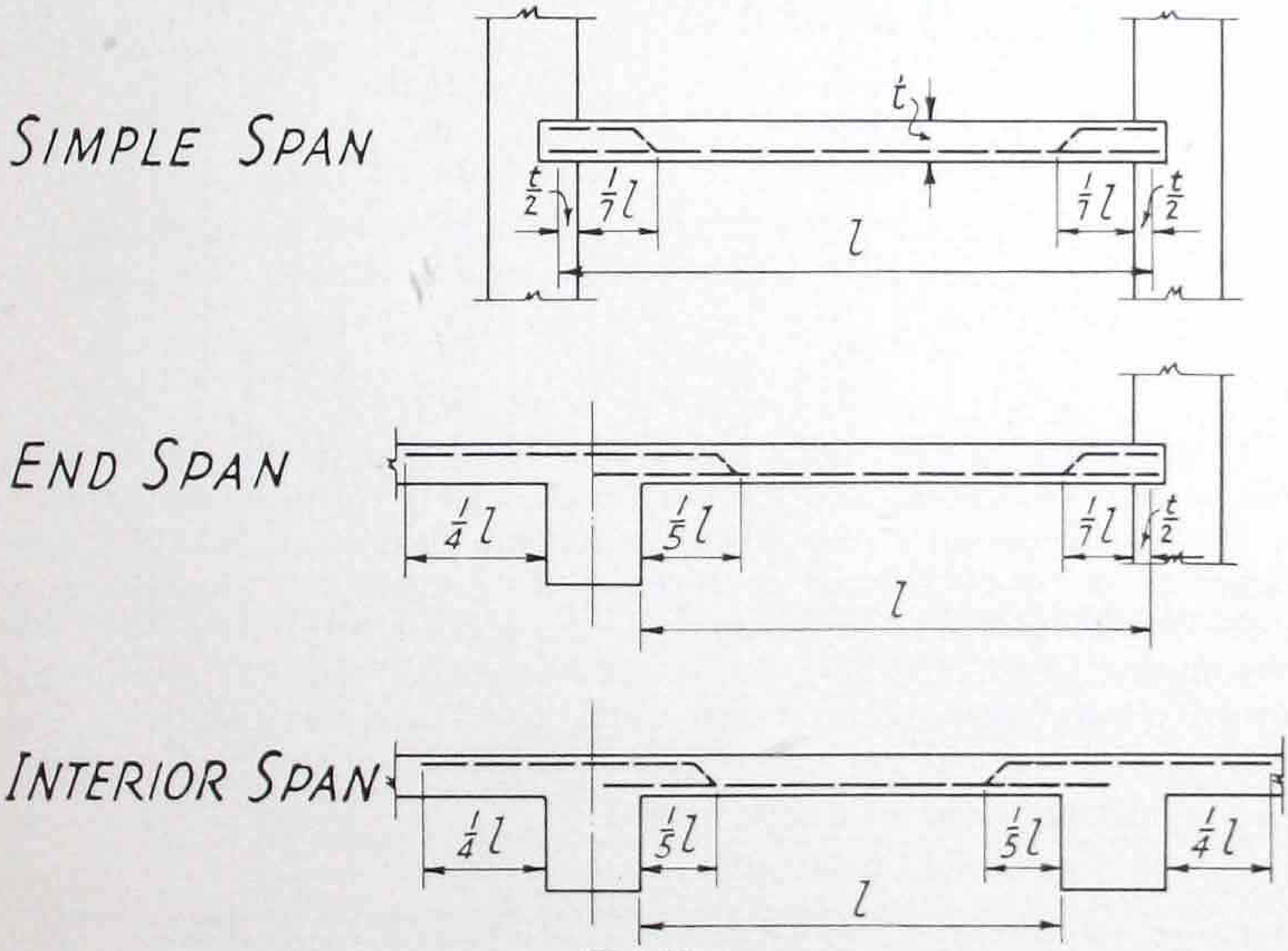


Fig. 12

is reached, which is equal to or greater than that required. The thickness of slab is shown in the first column of the table.

If the safe load is equal to the given load, use the size and number of bars shown in the fifth and sixth columns. If the safe load is larger than the given load, the steel area shown in the fourth column may be reduced by the proportion:

$$\frac{\text{given superimposed load} + \text{weight of slab}}{\text{safe superimposed load} + \text{weight of slab}}$$

The size and spacing of reinforcing steel may then be selected by use of Table 6, page 41. Problem 1, page 20, illustrates the use of Table 7.

Typical bar bending diagrams for simple, end and interior solid slab spans are shown in Fig. 12.

EXPLANATION OF TABLES No. 8 TO 12

The tables of safe loads for ribbed slabs are based upon clear spans, assumed 1-ft. less than the center to center spans, for both moment and shear. In the tables for floors involving tile fillers, 1½-in. has been added to the joist widths when computing the shearing value of the joist. This is done in order to take into account the shells of the tile in contact with the joist. Such allowance can only be made when the joints in the tile are staggered.*

The safe superimposed loads in Table 8 have been computed, taking into consideration the following weights of filler units (each unit 12-in. by 12-in. by the depth shown):

Depth of Tile In.	Weight per Unit Lbs.
4	16
6	22
8	30
10	36
12	40

If the weight of filler units used varies from that in the above table, the tabular values of safe superimposed loads must be corrected accordingly.

In order to design a ribbed slab having the clear span and the superimposed load in pounds per sq. ft. enter the proper table (depending on type of filler units) in the column for the given span; follow down the column until a safe load is reached equal or greater than the given load; read the slab dimensions and joist width in columns one and three. The area of steel required per joist is determined by the following formula:

$$A_S = \frac{\text{Design Load} + \text{Weight of Slab}}{\text{Load Coefficient}} \times \text{Steel Coefficient}$$

*The shells of the tile are considered effective as compression area for negative moments near supports. It is also assumed in all joist slab tables that compressive steel at the interior support of two spans is equal to that required at midspan for positive moment and at interior supports of three or more spans the compressive steel is one-half of the positive reinforcement. The length of embedment of straight bottom bars shall be not less than 20 diameters beyond end of the joist ribs.

The *Load Coefficient* is found in the table just above the safe load value for the particular span and slab dimensions. The *Steel Coefficient* is found opposite the safe load value in columns 6, 7 or 8, depending upon the condition of continuity.

Illustrative Problem

The following example illustrates the use of Tables 8 to 12, inclusive.

Design a tile and concrete joist slab, interior panel, having a clear span face to face of supporting beams of 16-ft. and carrying a superimposed load of 100 p.s.f. Enter Table 8, under span 16-ft., follow down the column to the first safe load value greater than 100 p.s.f.; namely, 107 p.s.f. In the first column it is found that an "8 + 2 Slab" is adequate using a 5-in. joist as indicated in Column 3. The weight of the slab, including the tile filler, is 75 p.s.f.

The load coefficient is 416 and the steel coefficient for the condition of continuity, $\frac{wl^2}{12}$ is 0.95. The steel area required is then obtained from the formula for A_S given above.

$$A_S = \frac{(100 + 75)}{416} \times 0.95 = 0.40 \text{ sq. in.}$$

Table 5 shows two ½-in. rd. bars have an area of 0.40 sq. in.

Typical bar bending diagrams for tile and metal pan filler and concrete joist slabs are shown in Fig. 13.

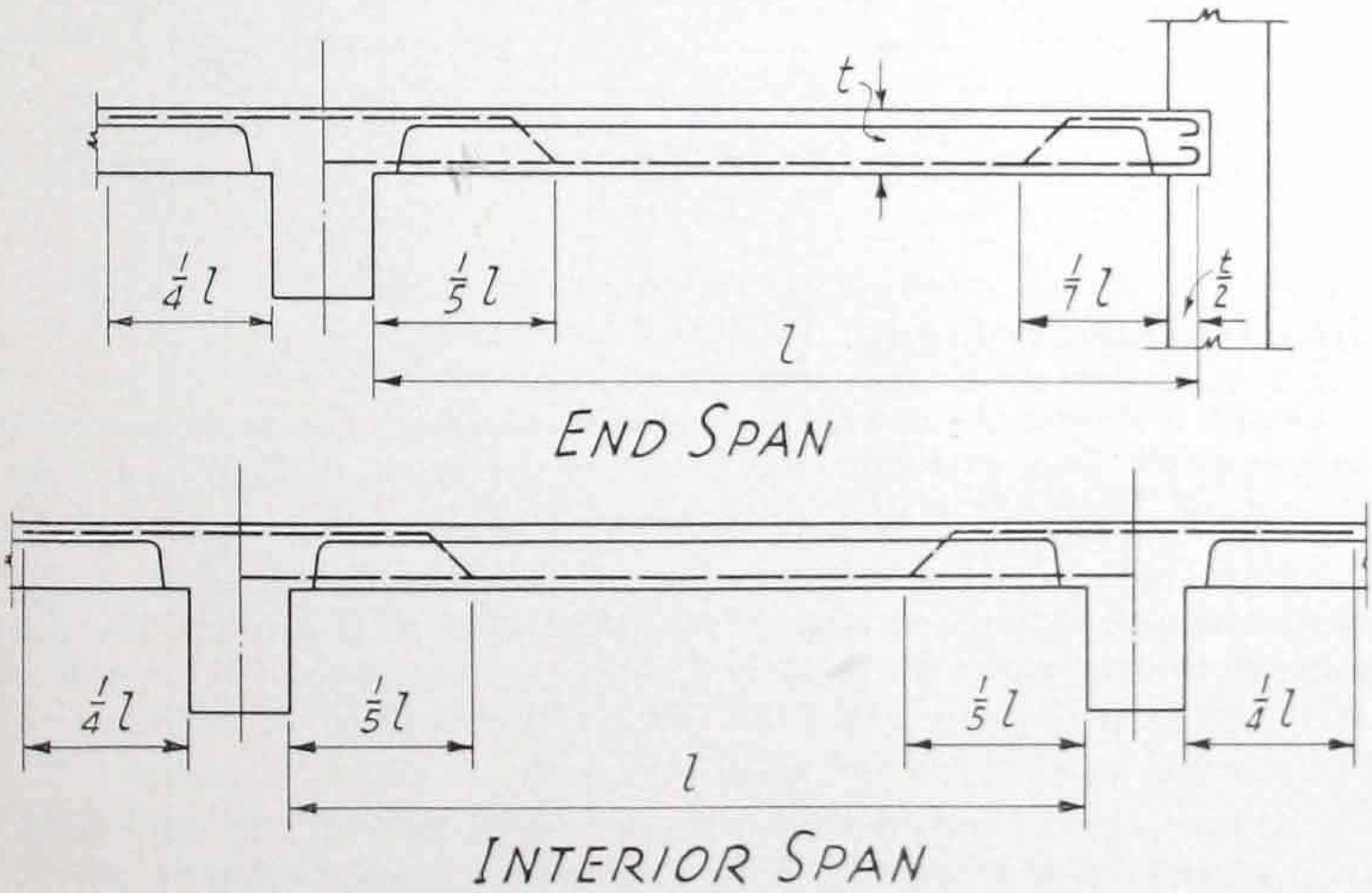


Fig. 13

EXPLANATION OF TABLES No. 13 TO 16

Table No. 13 is a safe load table for beams of simple span designed for a moment of $M = +\frac{1}{8}wl^2$ at the center of the span. Tables No. 14, 15 and 16 are for beams designed for moments at the support of $-\frac{1}{8}wl^2$, $-1/10wl^2$ and $-1/12wl^2$, respectively, and differ from the preceding tables in that the unit stress in the concrete, f_c, is taken as 900 p.s.i., instead of 800 p.s.i., as provided in the A. C. I. Code for compression in concrete at beam supports. Coefficients of wl^2 for various span arrangements are given in Table 1, page 14. Typical details for bending bars are given in Fig. 14.

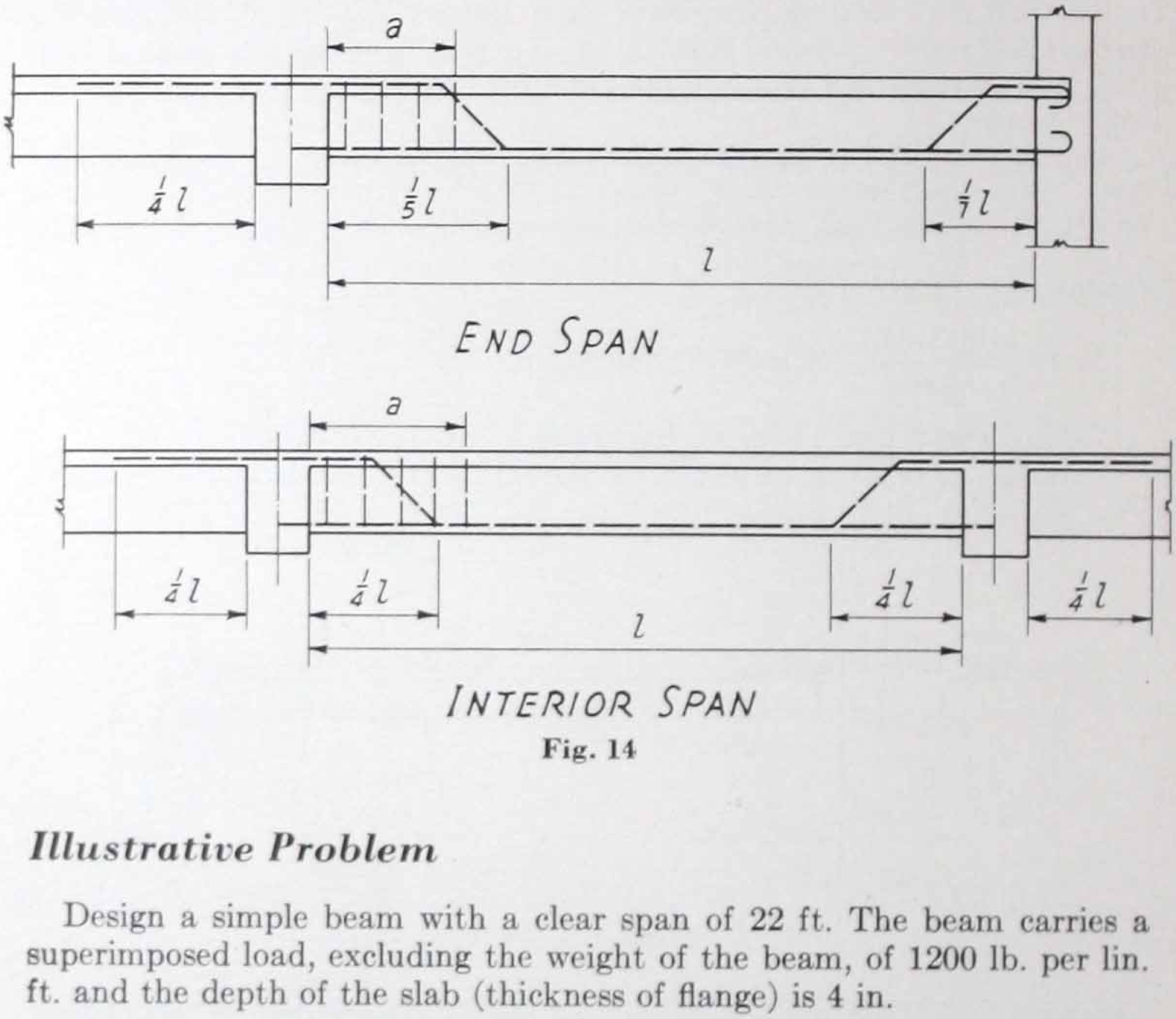


Fig. 14

Illustrative Problem

Design a simple beam with a clear span of 22 ft. The beam carries a superimposed load, excluding the weight of the beam, of 1200 lb. per lin. ft. and the depth of the slab (thickness of flange) is 4 in.

Enter Table No. 13 and follow down the column for "span – 22 ft." until a safe superimposed load greater than 1200 p.l.f. is found opposite a flange thickness of 4 in., namely 1230 p.l.f. The depth of beam will be 14 in. given in Column 1 and the width of web will be 12 in., shown in Column 3. The weight of the web is 125 p.l.f.

The area of steel required for a superimposed load of 1230 lb. per lin. ft. is 4.68 sq. in. as found in Column 7. This may be reduced in proportion to the actual total load on the beam.

$$A_S = 4.68 \times \frac{1200 + 125}{1230 + 125} = 4.58 \text{ sq. in.}$$

According to Table No. 5, this area can be obtained with three 1¼-in. sq. bars. (A_S = 4.68 sq. in.)

If the span had been 20 ft. the dimensions of the beam would be governed by shear and the area of steel would be determined by the design coefficients. The same dimensions would be required as in the previous case, the safe superimposed load being 1390 lb. per lin. ft. The steel coefficient, c_1, is 0.216 and $A_S = c_1 l = 0.216 \times 20 = 4.32$ sq. in. This area can be obtained with three 1-in. rd. bars and two 1-in. sq. bars. $A_S = 4.37$.

The bond stress must be checked and shear reinforcement provided if necessary to complete the beam design. See Problems 2 to 6 for the method to be used.

EXPLANATION OF TABLES No. 17 TO 22

The use of spans equal to clear distance between beam webs is specified in some building codes; in other codes, longer slab spans may be specified. In either case, the designer enters Tables No. 17 to 22 with values of *Spans in Feet* computed according to the code that governs; the use of the table is the same in either case.

The two-way concrete slabs in Tables No. 17 to 22 are designed according to the A. C. I. Code. The reinforcement given is that which is required in slab zones with maximum reinforcement, the balance of the reinforcement being determined as follows:

(1) Positive reinforcement adjacent to a continuous edge only and for width not exceeding one-fourth of the shorter dimension of the panel may be reduced 25 per cent.

(2) At a non-continuous edge, negative reinforcement per unit width, in amount at least as great as one-half that required for maximum positive moment for the center one-half of the panel, shall be provided across the entire width of the exterior support.

(3) The spacing of reinforcement shall be at most 2½ times the slab thickness and the ratio of reinforcement shall be at least 0.003.

Reinforcement in the long direction of the slab has been assumed to be in the top layer; some codes call for this reinforcement to be in the bottom layer. Economically, there is little difference between the two schemes.

Explanatory remarks, in addition to those in Problem 6, will be presented in the illustrative problem which follows. An end panel will be designed and the slab reinforcement detailed. The distribution of slab load to beams will also be discussed.

Illustrative Problem

Given the panel in Fig. 15: end span is in the short direction and interior span in the long direction, the distance between centerlines of beams being 18 ft. and 24 ft. as shown. Let the superimposed load be the same as in Problem 6: 82 p.s.f. Assume a beam width of 12 in. for interior short beams, 14 in. for interior long beam and 10 in. for exterior beam. Determine the slab thickness, number, size and length of bars required.

Design. The ratio of long to short clear span is

$$\frac{24.0 - (0.5 + 0.5)}{18.0 - (0.6 + 0.4)} = \frac{23.0}{17.0} = 1.35$$

For design of slab, use Table No. 19 (Ratio 1.4 to 1.0). In column headed *23.8 × 17* and for *End-Interior* condition of continuity, a 6-in. slab capable of supporting a superimposed load of 161 p.s.f. is seen to be sufficient. The 6-in. slab weighs 75 p.s.f.

Reinforcement given in table is:

Short way: ½-in. rd. bars at 4-in. o.c. (area per linear foot = 0.60).

Long way: ½-in. rd. bars at 6-in. o.c. (area per linear foot = 0.40).

The 6-in. slab with this reinforcement can carry safely a total load of 161 + 75 = 236 p.s.f., but the actual load is only 82 + 75 = 157 p.s.f. It is not permissible under the Code requirements to use a slab thinner than 6 in. for the conditions given. The reinforcement, however, may be reduced in the proportion of $\frac{157}{236} = 0.67$, but it shall be not less than that specified in point (3), which gives for minimum bar areas:

Short way: $0.003 \times 12 \times (6 - 1) = 0.18$ sq. in.

Long way: $0.003 \times 12 \times (6 - 1\frac{1}{2}) = 0.17$ sq. in.

Reinforcement required for strength according to Table No. 19 with correction allowed as calculated above is:

Short way ($0.67 \times 0.60 = 0.40$): ½-in. rd. bars at 6-in. o.c.

Long way ($0.67 \times 0.40 = 0.27$): ½-in. rd. bars at 9-in. o.c.

This reinforcement is to be placed in center bands. In the outer bands, the extent of which will be discussed later under detailing, the reinforcement may be reduced according to (1) as follows:

Short way ($0.75 \times 0.67 \times 0.60 = 0.30$): ½-in. rd. bars at 8-in. o.c.

Long way ($0.75 \times 0.67 \times 0.40 = 0.20$): ½-in. rd. bars at 12-in. o.c.

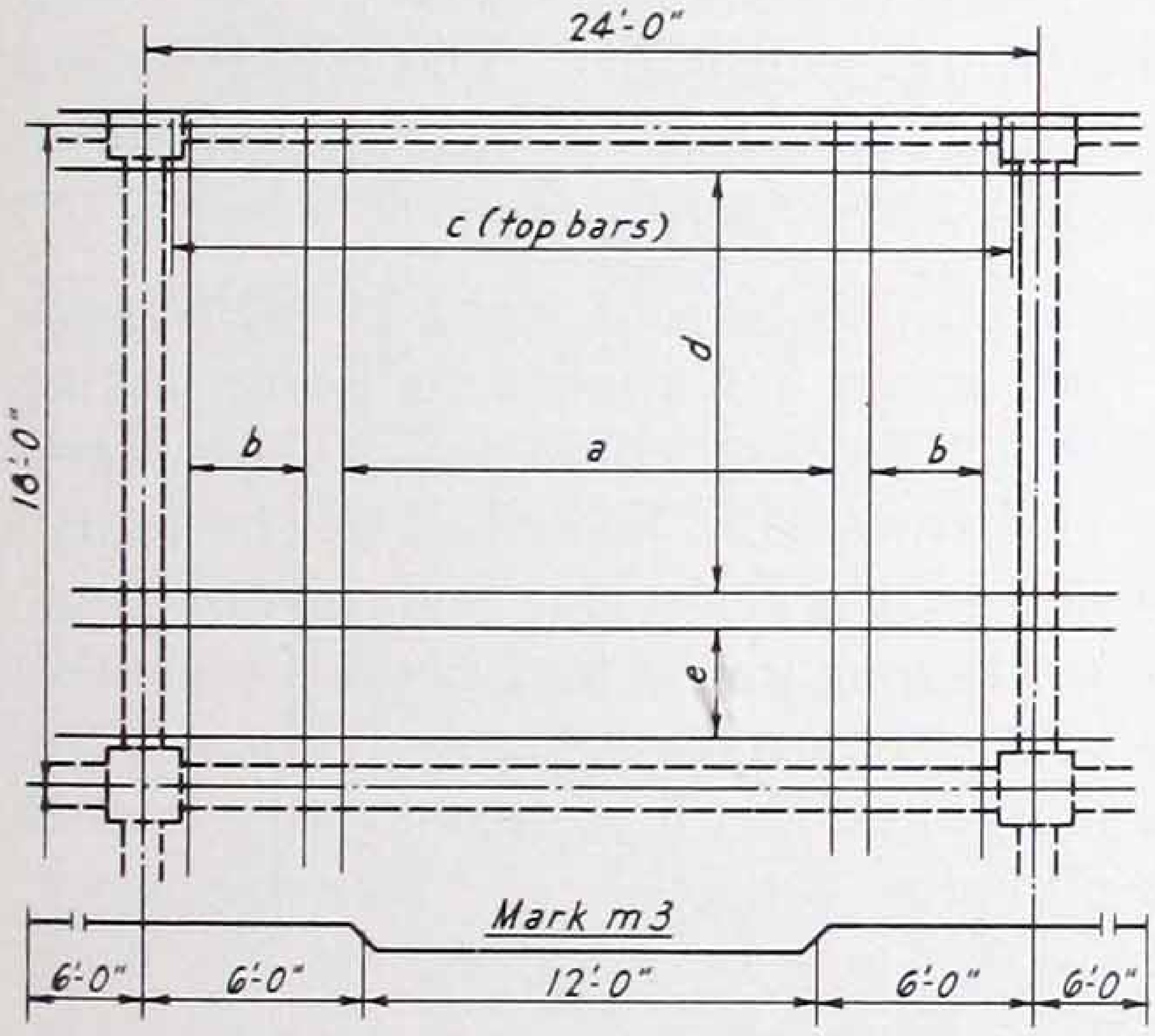
All of the four spacings are smaller than the maximum allowed in (3): $2\frac{1}{2} \times 6 = 15$ in.

Detailing

For the slab designed above, placing plan, bar schedule and bending details are shown in Fig. 15. According to (1), the width of all outer bands, *b* and *e*, is $\frac{1}{4} \times 17.0 = 4.25$, where 17.0 is the *shorter* panel dimension.

The bars in band *a* are ½-in. rd. at 6-in. o.c., the band width $23.0 - 2 \times 4.25 = 14.5$ ft., and the number of bars $\frac{12 \times 14.5}{6} = 29$, of which 15 are straight and 14 are bent. For two bands *b*, the number of bars is $\frac{12 \times 2 \times 4.25}{8} = 12$, of which 6 are straight and 6 are bent.

For the outer band, *e*, in the long direction, the bars are ½-in. rd. at 12-in. o.c., and the number of bars is $\frac{12 \times 4.25}{12} = 4$, of which 2 are straight and 2 are bent. The remainder of the short panel width, $\frac{3}{4} \times 17.0$, has ½-in. rd. bars spaced 9-in. o.c., and the number of bars in this band, *d*, is $\frac{12 \times 0.75 \times 17.0}{9} = 17$, of which 9 are straight and 8 are bent.



Band	No.	Type	Size	Length	Mark	Spacing
a	15	str.	½φ	18'-0"	–	6" o.c.
	14	bt.		23'-6"	m1	
b	3	str.	½φ	18'-0"	–	8" o.c.
	3	bt.		23'-6"	m1	
c	–	–	–	–	–	–
	18	bt.	⅜φ	5'-3"	m2	15" o.c.
d	9	str.	½φ	24'-0"	–	9" o.c.
	8	bt.		36'-3"	m3	
e	2	str.	½φ	24'-0"	–	12" o.c.
	2	bt.		36'-3"	m3	

Note: Bars in a and b in bottom layer

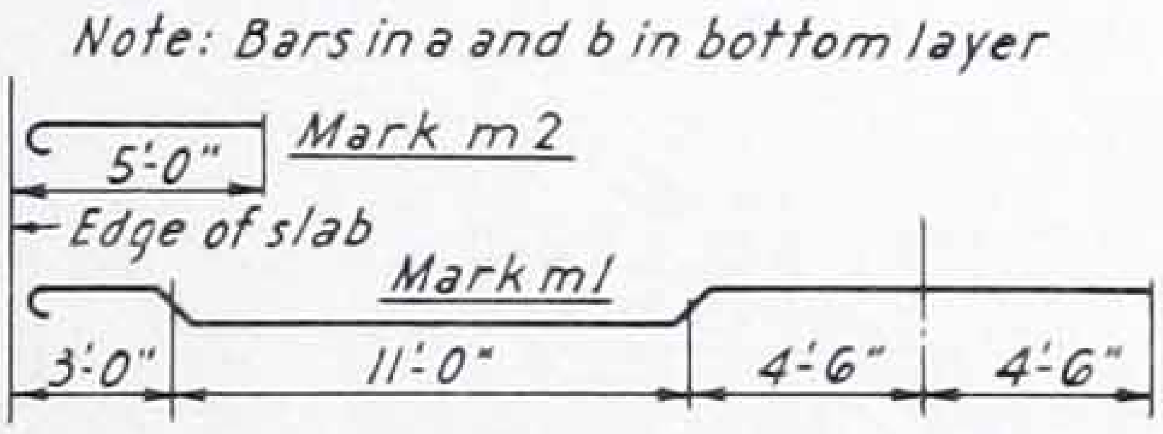


Fig. 15—PART FRAMING PLAN AND BAR SCHEDULE

Top bars in band *c* shall, according to code requirement, have an area per linear foot equal to one-half of that of bars in band *a*; that is, the reinforcement in *c* shall be ½-in. rd. bars at 12-in. o.c., or equal. The bent bars in *b*, ½-in. rd. at 16-in. are deficient in area, and all bent bars are bent up too close to the exterior beam to be fully effective as top bars. The deficiency will be made up by using additional top bars ⅜-in. rd. at 15-in. o.c., the total number in *c* being $\frac{12 \times 23}{15} = 18$ bars, which are hooked.

Distribution of Load from Two-Way Slabs to Beams

The load transmitted from a two-way solid slab to the supporting beams according to the A. C. I. Code, may be determined as follows: Let

R = Slab reaction on beam in lb. per lin. ft.

w = Total slab load in p.s.f.

L = Longer span in ft.

l = Shorter span in ft.

The reaction on the beams is then:

	For bending		*For shear*
On longer beam:	$R_L = (1 - er) \times \frac{wl}{2}$	and	$(1 - r) \times \frac{wl}{2}$
On shorter beam:	$R_l = (1 - er) \times \frac{wL}{2}$	and	$(1 - r) \times \frac{wL}{2}$

The quantities $(1 - er)$ and $(1 - r)$ are used to denote a coefficient which is a function of L/l and the condition of continuity. The meaning and application of these quantities will be explained and illustrated in connection with Fig. 16, which refers to two-way slabs with ratio of $L : l :: 1.4 : 1.0$.

Fig. 16 shows nine groups with from one to nine slabs in each group marked from (1) to (9). Note that group 3-3 applies to floors having three or more spans in either direction. The numbers in parentheses represent all the types of "Condition of Continuity" described in the fourth and fifth columns of the two-way slab tables. Refer, for example, to Table No. 19, in which the condition of continuity in the first line for each slab thickness is: "Short Way Simple" and "Long Way Simple." Considering the factors applying to bending in beams, the first line in the box at the side of Table No. 19 gives—for the condition of "Simple-Simple"—the two values of $(1 - er)$: 0.835 (for long beam) and 0.440 (for short beam). The condition of continuity: Simple-Simple, and the numbers: 0.835 and 0.440 are shown in slab (1) adjacent to the beams to which they apply. Similarly, each of the nine lines of two numbers in the boxes and the corresponding description of the continuity in the fourth and fifth columns given in the same horizontal line are shown in Fig. 16. If necessary, similar charts may readily be sketched for ratios other than 1.4 : 1.0, and the values of $(1 - er)$ and $(1 - r)$ transferred from table to chart-form.

To illustrate the use of Fig. 16, consider again Fig. 15 and assume that the slab shown is part of a framing plan such as 3-3 in Fig. 16, the slab in Fig. 15 being the slab marked (6) in Fig. 16. The distance between center-lines of beams in slabs (5), (6) and (9) is 18 ft. the short way and 24 ft.

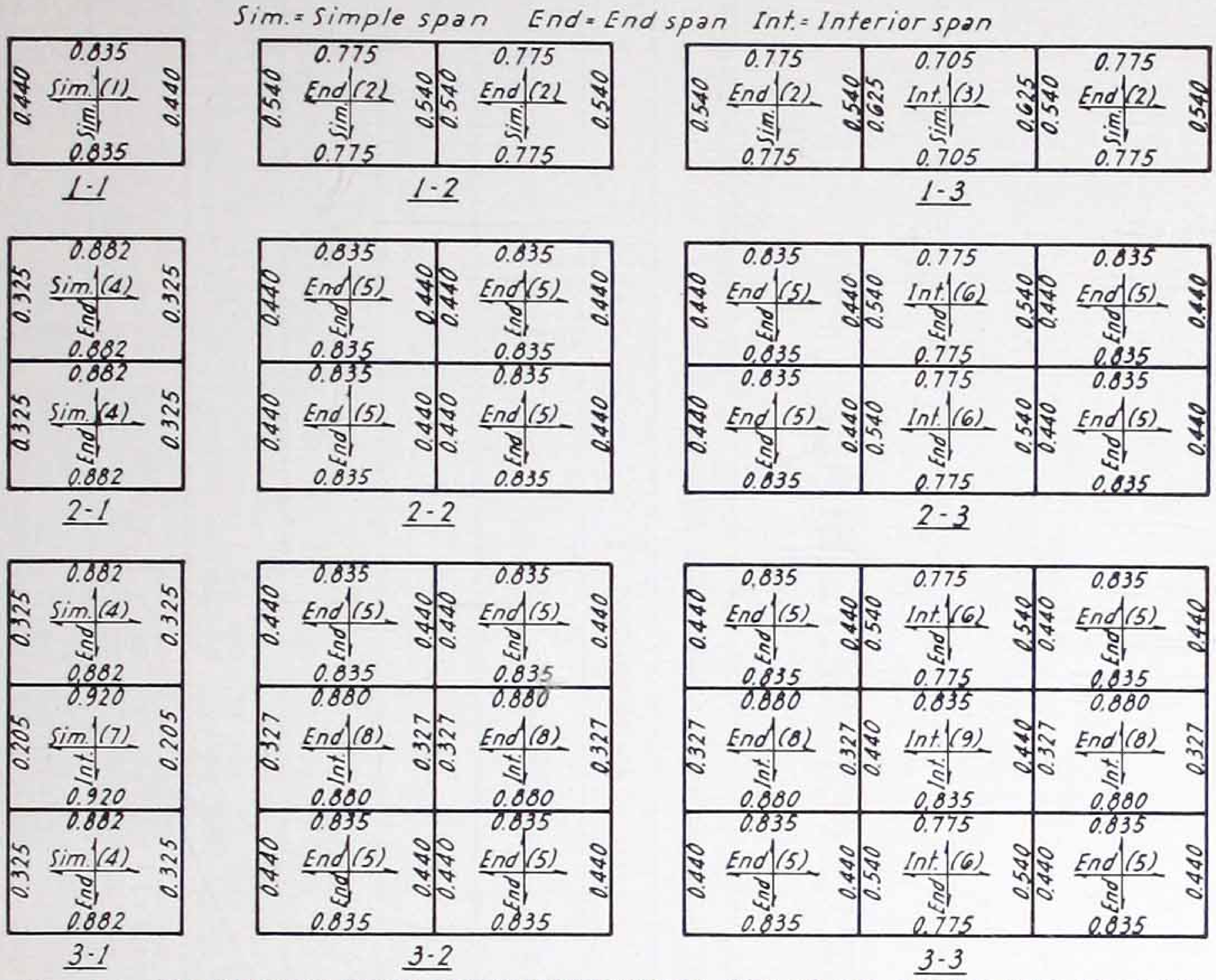


Fig. 16—FACTORS FOR DISTRIBUTION OF SLAB LOAD TO BEAMS FOR RATIO OF LONG TO SHORT SPAN = 1.4:1.0 FOR CALCULATION OF BEAM MOMENTS. SEE TABLE 19 FOR SIMILAR FACTORS FOR DETERMINATION OF BEAM SHEARS.

the long way. Determine equivalent loads to be used in calculating moments in beams along the four sides of slab (6), the total load being

$82 + 69 = 151$ p.s.f. on slab (9)
$82 + 75 = 157$ p.s.f. on slab (6)
$82 + 81 = 163$ p.s.f. on slab (5)

The reaction on the beams in lb. per lin. ft. is as follows, exclusive of the weight of beam webs and using the formula given above with the value of $(1 - er)$ taken from slabs (5), (6) and (9) in Fig. 16 or from lines 5, 6 and 9 in the box in Table No. 19:

Spandrel Beam: $0.775 \times 157 \times \frac{18}{2} = 1100$

Long Int. Beam: $0.775 \times 157 \times \frac{18}{2} + 0.835 \times 151 \times \frac{18}{2} = 2230$

Short Int. Beams: $0.540 \times 157 \times \frac{24}{2} + 0.440 \times 163 \times \frac{24}{2} = 1880$

These loads plus the weight of beam webs are to be used for calculating beam moments. For beam shears, use the same procedure but substitute values of $(1 - r)$ for $(1 - er)$.

$f_s = 20,000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
¾″ clear fireproofing

TABLE No. 7 — ONE-WAY SOLID CONCRETE SLABS

Total Thickness of Slab	Weight of Slab per Sq. Ft.	Volume of Concrete per Sq. Ft.	Required Steel Area	Reinforcing Steel		Condition of Continuity of Span	SAFE SUPERIMPOSED LOAD IN LB. PER SQ. FT. — SPANS IN FEET																													
				Size	Spacing		3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11	11½	12	12½	13	13½	14	14½	15	15½	16	16½	17	17½	18
In.	Lb.	Cu. Ft.	Sq. In.	In.	In.	Span																														
3	38	0.250	0.19	⅜φ	7	Simple	326	240	182	140	109	86	67	53	41																					
						End		309	236	184	146	116	94	75	61	49	39																			
						Interior			292	229	183	146	120	98	81	66	54	44	36																	
3½	44	0.292	0.23	⅜φ	5½	Simple			296	231	183	147	119	96	78	63	51	41																		
						End				300	240	195	159	131	109	90	75	62	51	42	31															
						Interior					297	242	200	167	139	117	99	83	70	59	49	41	34													
4	50	0.333	0.28	⅜φ	4½	Simple					275	223	182	150	125	103	86	71	59	48	39															
						End						292	241	201	168	142	120	102	86	73	56	47	39	32												
						Interior							299	251	212	181	154	132	114	98	84	72	61	52	44	37										
4½	56	0.375	0.32	½φ	7½	Simple						301	249	206	172	145	122	103	87	73	61	50	41	33												
						End								272	230	196	167	143	122	105	84	71	60	51	42	35										
						Interior									288	246	211	182	158	137	119	104	90	78	67	58	50	42	36							
5	63	0.417	0.36	½φ	6½	Simple								280	235	199	170	144	123	105	89	76	64	54	44	36										
						End										265	227	196	169	147	119	103	89	77	65	56	47	39	33							
						Interior											286	249	216	189	165	145	127	112	98	86	75	65	57	49	42	35				
5½	69	0.458	0.41	½φ	5½	Simple										264	226	194	167	144	124	107	92	79	67	57	48	39								
						End												259	226	197	162	141	123	108	93	81	71	61	52	44	37	30				
						Interior														250	220	195	172	152	135	120	106	94	83	73	64	56	48	41	35	
6	75	0.500	0.45	½φ	5	Simple											288	248	216	187	163	142	123	107	93	80	69	59	50	41	34					

6½	81	0.541	0.50	½φ	4½	Simple													271	237	207	181	159	139	122	107	93	81	70	60	51	45	[illegible]			
						End															264	233	206	183	162	144	127	113	100	88	77	67	59	51	43	36
						Interior																	279	250	224	201	180	162	145	130	117	105	94	84	74	66
7	88	0.584	0.53	⅝φ	6½	Simple														282	247	217	192	168	148	131	115	101	88	76	66	56	48	40	32	
						End																278	247	220	196	174	155	138	122	109	96	85	74	65	56	48
						Interior																			267	240	216	195	176	158	143	128	116	104	93	83
7½	94	0.625	0.58	⅝φ	6	Simple																266	235	208	185	163	145	128	113	99	87	76	66	57	48	40
						End																		268	239	214	191	171	154	137	123	109	97	86	76	67
						Interior																					264	239	216	196	178	161	146	132	119	107
8	100	0.667	0.62	⅝φ	5½	Simple																		251	223	199	177	158	140	124	110	97	85	75	65	56
						End																				258	231	208	188	169	151	136	122	109	97	86
						Interior																							261	237	215	197	179	163	148	134
8½	106	0.709	0.66	¾φ	8	Simple																			260	232	208	186	166	148	132	117	104	92	81	70
						End																					269	242	219	198	179	160	145	130	117	105
						Interior																									251	229	208	190	174	159
9	113	0.750	0.71	¾φ	7½	Simple																				272	244	219	197	176	158	142	126	112	99	88
						End																							257	233	212	192	173	157	142	127
						Interior																										268	245	225	206	188
9½	119	0.791	0.75	¾φ	7	Simple																						256	231	207	187	168	151	135	121	108
						End																								273	247	226	205	186	168	152
						Interior																												263	241	221
10	125	0.833	0.80	¾φ	6½	Simple																							268	242	219	198	179	161	145	130
						End																										261	239	217	198	180
						Interior																														257

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
Max. $v = 40$ p.s.i.
¾″ clear fireproofing

TABLE No. 8—CONCRETE OR CLAY TILE AND CONCRETE JOISTS

$A_S = \frac{\textit{Total} \text{ Load per sq. ft.}}{\text{Load Coeff.}} \times$ Steel Coeff. (sq. in. per joist)

Tiles to be staggered.

(1½″ Added to effective width of joist.)

Slab (Tile + Topping) Total Depth	Effective Depth	Width of Joist	Weight per Sq. Ft. Slab	Volume of Concrete Cu. Ft. per Sq. Ft.	STEEL COEFFICIENTS FOR MOMENTS OF			SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET																		
In.	In.	In.	Lb.		$\frac{wl^2}{8}$	$\frac{wl^2}{10}$	$\frac{wl^2}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
					Load Coefficient→			374	309	260	221	191	166	146	129											
4+2	4.88	4	49	0.250	0.88	0.70	0.58	91	79	68	59	51	45	39												
		5	51	0.265	0.93	0.75	0.62	106	90	79	69	61	53	47	41											
		6	52	0.278	0.99	0.79	0.66	119	103	90	79	70	62	54	48											
					Load Coefficient→			455	376	316	269	232	202	178	157	140										
4+2½	5.38	4	55	0.292	0.97	0.77	0.64	100	86	74	64	56	48	42	36											
		5	57	0.306	1.03	0.82	0.68	116	100	87	76	66	58	51	45	39										
		6	58	0.319	1.09	0.87	0.73	130	113	99	87	76	67	59	52	46										
					Load Coefficient→			544	449	378	322	277	242	212	188	168										
4+3	5.88	4	62	0.333	1.06	0.85	0.70	108	92	79	68	59	51	44	38											
		5	64	0.348	1.12	0.90	0.75	125	108	93	81	71	62	54	47	41										
		6	65	0.361	1.19	0.95	0.79	141	122	107	93	82	72	64	56	49										
					Load Coefficient→			715	591	497	423	365	318	280	248	221	198	179	162	148						
6+2	6.88	4	60	0.292	1.18	0.94	0.78	141	123	107	95	83	74	65	58	51	46	40								
		5	62	0.314	1.25	1.00	0.83	162	142	124	110	98	87	78	70	62	56	50	44	40						
		6	65	0.333	1.32	1.06	0.88	178	156	137	122	109	97	87	78	70	63	56	51	45						
					Load Coefficient→			835	690	580	494	426	371	326	289	258	231	208	189	172						
6+2½	7.31	4	66	0.333	1.30	1.04	0.87	145	126	110	96	85	75	66	58	51	45	39								
		5	68	0.356	1.38	1.11	0.92	167	146	128	113	100	89	79	70	62	56	49	44	39						
		6	71	0.375	1.47	1.17	0.98	185	162	143	126	112	100	89	80	71	64	57	51	45						
					Load Coefficient→			961	794	667	569	491	427	375	332	296	266	240	218	198						

6+3	7.81	4	72	0.375	1.40	1.12	0.94	154	133	116	101	89	78	69	60	53	46	40	35							
					Load	Coefficient→		1065	880	740	630	544	473	416	368	328	295	266	241	220	201	185	170			
8+2	8.81	4	73	0.333	1.34	1.07	0.89	189	165	145	129	114	102	91	81	72	65	58	52	46	41	36				
		5	75	0.362	1.42	1.14	0.95	217	191	168	149	133	119	107	97	87	79	71	64	58	52	47	42			
		6	78	0.388	1.51	1.20	1.00	240	211	187	166	149	134	120	109	98	89	81	73	66	60	54	49			
					Load	Coefficient→		1280	1058	889	756	654	569	500	442	395	354	320	290	264	242	222	205			
8+2½	9.31	4	79	0.375	1.54	1.23	1.03	195	169	149	131	116	103	92	82	73	65	57	51	45	40					
		5	81	0.404	1.64	1.31	1.09	226	196	173	153	137	122	109	98	88	79	71	64	57	51	46	40			
		6	84	0.430	1.73	1.39	1.16	248	218	193	172	153	137	123	111	100	91	82	74	67	60	54	49			
					Load	Coefficient→		1458	1215	1012	862	744	648	569	504	450	404	364	330	301	276	253	233			
8+3	9.75	4	85	0.416	1.69	1.36	1.13	198	172	151	133	117	103	92	81	72	64	56	50	43	38					
		5	88	0.446	1.80	1.44	1.20	228	199	175	155	138	122	109	98	87	78	70	62	55	49	43	38			
		6	91	0.473	1.91	1.53	1.27	253	222	195	173	155	138	124	111	100	90	81	73	65	58	52	46			
					Load	Coefficient→		1433	1184	995	848	732	637	560	496	442	397	358	325	296	271	249	229	212	197	183
10+2	10.81	4	82	0.375	1.44	1.16	0.96	246	216	191	170	152	136	123	110	100	90	81	74	67	60	54	49	44	39	
		5	87	0.412	1.53	1.23	1.02	277	244	217	193	173	156	141	127	115	105	95	86	78	71	65	59	53	48	43
		6	90	0.445	1.62	1.30	1.08	307	270	241	215	193	174	158	143	130	119	108	99	90	82	75	69	62	57	51
					Load	Coefficient→		1722	1422	1197	1019	878	765	672	595	531	476	430	390	356	325	299	275	254	236	220
10+2½	11.25	4	88	0.416	1.69	1.35	1.13	247	217	191	170	151	135	122	109	98	88	79	71	64	57	51	46	38	36	
		5	93	0.454	1.80	1.44	1.20	290	246	218	194	173	156	140	126	114	103	93	84	76	69	62	56	50	45	40
		6	96	0.486	1.90	1.52	1.27	310	273	243	216	194	175	158	143	130	118	107	97	88	80	73	66	60	54	49
					Load	Coefficient→		1998	1650	1388	1182	1020	888	780	691	616	554	499	453	413	378	347	320	296	274	255
10+3	11.75	4	95	0.458	1.90	1.52	1.27	252	220	194	172	153	136	122	109	97	87	78	70	62	55	49	43	38		
		5	99	0.495	2.02	1.62	1.35	287	252	223	198	177	158	142	128	115	104	94	85	76	69	62	55	49	44	39
		6	102	0.528	2.14	1.71	1.43	318	280	248	221	198	178	160	145	131	119	108	98	89	80	73	66	59	53	48
					Load	Coefficient→		1810	1496	1258	1071	924	804	706	626	559	501	452	410	372	342	314	289	268	248	231
12+2	12.81	4	92	0.417	1.52	1.21	1.01	301	265	236	210	188	170	154	139	126	114	104	95	86	79	71	65	59	53	48
		5	97	0.460	1.61	1.29	1.08	340	301	267	239	215	194	176	160	146	133	121	111	101	93	85	78	71	65	59
		6	101	0.500	1.71	1.37	1.14	375	332	296	265	239	217	197	179	163	149	137	125	115	106	97	89	82	75	69
					Load	Coefficient→		2182	1803	1516	1290	1113	970	852	755	673	605	545	494	451	412	379	349	323	300	278
12+2½	13.25	4	98	0.458	1.80	1.44	1.20	303	267	236	210	188	169	152	138	125	113	102	93	84	76	69	62	56	50	45
		5	103	0.502	1.91	1.53	1.27	343	302	269	240	216	194	176	159	145	132	120	109	100	91	83	75	69	62	56
		6	107	0.542	2.02	1.62	1.35	378	333	297	266	239	216	196	178	162	148	135	124	113	103	95	87	79	72	66
					Load	Coefficient→		2545	2105	1768	1507	1300	1132	1006	880	785	705	636	576	526	481	441	407	376	349	325
12+3	13.75	4	104	0.500	2.04	1.63	1.36	307	270	239	212	190	170	153	138	124	112	102	92	83	75	67	60	54	48	43
		5	109	0.545	2.17	1.74	1.45	348	306	272	243	218	196	177	160	145	131	119	109	99	90	81	74	67	60	54
		6	113	0.583	2.30	1.84	1.53	385	340	302	270	243	219	198	180	163	149	136	124	113	103	94	86	78	71	64

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
Max. $v = 40$ p.s.i.
¾" clear fireproofing

TABLE No. 9 — 20″ METAL PANS AND CONCRETE JOISTS (STRAIGHT PANS)

$$A_s = \frac{\textit{Total} \text{ Load per sq. ft.}}{\text{Load Coeff.}} \times \text{Steel Coeff. (sq. in. per joist)}$$

Slab (Pan + Topping) Total Depth	Effective Depth	Width of Joist	Weight per Sq. Ft. Slab	Volume of Concrete Cu. Ft. per Sq. Ft.	STEEL COEFFICIENTS FOR MOMENTS OF			SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET																		
In.	In.	In.	Lb.		$\frac{wl^2}{8}$	$\frac{wl^2}{10}$	$\frac{wl^2}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
					Load	Coefficient→		705	582	490	417	360	313	275												
6+2	6.81	4	39	0.26	1.75	1.40	1.17	57	48	41																
		5	42	0.28	1.83	1.46	1.22	73	63	54	46	40														
		6	44	0.29	1.90	1.52	1.27	89	77	67	58	51	45	39												
					Load	Coefficient→		836	691	581	495	427	371	327												
6+2½	7.31	4	46	0.30	1.95	1.56	1.30	56	47	39																
		5	48	0.32	2.04	1.63	1.36	75	63	54	46	39														
		6	50	0.33	2.11	1.69	1.41	92	79	68	59	51	44	38												
					Load	Coefficient→		1053	871	732	624	538	468	412	365	325	298									
8+2	8.75	4	45	0.30	2.00	1.60	1.34	81	70	60	52	45														
		5	48	0.32	2.09	1.67	1.39	103	90	78	68	60	53	46	41											
		6	51	0.34	2.17	1.74	1.45	123	107	94	83	73	65	58	51	46	41									
					Load	Coefficient→		1264	1045	878	748	645	562	494	438	390										
8+2½	9.25	4	51	0.34	2.30	1.84	1.53	81	68	58	50	43														
		5	54	0.36	2.40	1.92	1.60	104	89	77	67	59	51	45												
		6	57	0.38	2.49	1.99	1.66	125	108	95	83	73	64	57	50	44										
					Load	Coefficient→		1437	1178	990	845	728	634	557	493	440	395	366	323	295						
10+2	10.75	4	51	0.34	2.17	1.73	1.45	107	92	80	70	62	54	47	42											

					Load Coefficient →			1720	1422	1195	1017	877	765	672	595	530	476	430	390							
10+2½	11.25	4	57	0.38	2.54	2.03	1.69	106	91	78	68	59	51	44	39											
		5	61	0.40	2.64	2.12	1.76	134	116	101	89	78	69	61	53	47	41									
		6	65	0.43	2.75	2.20	1.83	160	139	122	108	95	85	75	67	60	53	47	42							
					Load Coefficient →			1998	1650	1388	1182	1020	888	780	691	616	554	499	453							
10+3	11.75	4	63	0.42	2.86	2.28	1.90	105	90	77	66	57	49	42	36											
		5	67	0.45	2.97	2.38	1.98	134	116	101	88	76	67	58	51	45	39									
		6	71	0.47	3.09	2.47	2.06	161	140	123	108	95	84	74	66	58	51	45	39							
					Load Coefficient →			1802	1490	1252	1067	920	801	705	623	556	499	450	408	372	341	313	288	266	247	230
12+2	12.75	5	61	0.41	2.38	1.91	1.59	166	145	128	113	101	90	81	72	65	58	52	47	42						
		6	66	0.44	2.48	1.98	1.65	196	172	152	135	121	108	97	88	79	72	65	58	53	48	43				
		7	70	0.46	2.55	2.06	1.72	224	197	175	156	140	126	113	103	93	85	77	70	63	58	52	47	43	39	
		8	74	0.49	2.67	2.14	1.78	250	221	196	176	158	142	129	117	106	97	88	80	73	67	61	56	51	46	42
					Load Coefficient →			2186	1807	1518	1292	1115	972	854	756	675	605	546	495	452	413	379	350	324	300	279
12+2½	13.25	5	68	0.45	2.82	2.25	1.88	165	144	126	111	98	87	77	69	61	54	48	43							
		6	72	0.48	2.93	2.34	1.95	196	172	152	134	120	107	96	86	77	69	62	56	50	45	40				
		7	76	0.51	3.04	2.43	2.03	226	198	176	156	140	125	113	101	92	83	75	68	61	55	50	45	40		
		8	80	0.53	3.16	2.52	2.10	253	223	197	176	158	142	128	116	105	95	86	78	71	64	59	53	48	43	39
					Load Coefficient →			2543	2103	1766	1503	1298	1130	995	880	785	705	636	577	526	481	441	407	376	349	
12+3	13.75	5	74	0.49	3.19	2.55	2.13	165	143	125	109	96	85	75	66	58	51	45	39							
		6	78	0.52	3.32	2.66	2.21	198	173	152	134	119	106	94	84	75	67	60	53	47	42					
		7	82	0.55	3.45	2.76	2.30	228	200	176	156	139	124	111	100	90	81	73	65	59	53	47	42			
		8	86	0.57	3.58	2.86	2.39	256	224	198	176	158	142	127	115	104	94	85	76	69	62	56	50	45	40	
					Load Coefficient →			2648	2189	1838	1566	1351	1176	1034	916	817	734	662	600	546	500	460	424	392	363	338
14+2½	15.25	5	75	0.50	2.92	2.34	1.95	195	171	150	133	118	105	94	84	75	67	60	54	48	42					
		6	80	0.53	3.04	2.43	2.03	233	204	181	161	143	128	115	104	94	84	76	69	62	56	50	45	40		
		7	85	0.56	3.16	2.53	2.11	266	235	208	185	166	149	135	122	110	100	91	82	75	68	61	55	50	45	40
		8	89	0.59	3.27	2.62	2.18	298	263	234	209	188	169	153	139	126	115	104	95	87	79	72	66	60	54	49
					Load Coefficient →			3100	2560	2153	1833	1580	1378	1210	1072	957	859	775	703	641	586	538	496	458	425	396
14+3	15.75	5	81	0.54	3.36	2.69	2.24	195	170	149	131	116	103	92	81	72	64	57	50	44	39					
		6	86	0.57	3.49	2.79	2.33	233	204	180	160	142	127	113	102	91	82	73	66	59	53	47	42			
		7	91	0.60	3.63	2.90	2.42	267	235	208	185	165	148	133	120	108	97	88	80	72	65	58	52	47	42	
		8	95	0.63	3.76	3.01	2.51	300	264	234	209	187	169	152	137	125	113	102	93	84	77	69	63	57	51	46

f_s = 20,000 p.s.i.
f_c = 800 p.s.i.
n = 15
Max. v = 40 p.s.i.
¾" clear fireproofing

TABLE No: 10 — 20" METAL PANS AND CONCRETE JOISTS (TAPERED PANS)

$$A_s = \frac{\textit{Total}\ \text{Load per sq. ft.}}{\text{Load Coeff.}} \times \text{Steel Coeff. (sq. in. per joist)}$$

Slab (Pan + Topping) Total Depth	Effective Depth	Width of Joist	Approx. Wt. Per Sq. Ft. of Slab	STEEL COEFFICIENTS FOR MOMENTS OF			SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET																		
In.	In.	In.	Lb.	$\frac{wl^2}{8}$	$\frac{wl^2}{10}$	$\frac{wl^2}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6+2	6.81			Load Coefficient→			705	582	490	417	360	313	275	244	218	195	176	160	146	133	122	113			
		4	43	1.75	1.40	1.17	150	132	118	105	95	85	77	70	64	58	53	49	45	41					
		5	46	1.83	1.46	1.22	162	143	127	114	103	93	84	76	69	63	58	53	48	44	41				
		6	48	1.90	1.52	1.27	174	154	137	123	111	100	91	83	75	69	63	58	53	48	45	41			
6+2½	7.31			Load Coefficient→			836	691	581	495	427	371	327	289	258	232	209	189	173	158	145	134			
		4	50	1.95	1.56	1.30	155	136	121	108	96	87	78	71	64	58	52	48	43						
		5	52	2.04	1.63	1.36	169	148	132	118	106	95	86	78	71	64	58	53	48	44	40				
		6	54	2.11	1.69	1.41	183	162	143	128	115	104	94	85	78	71	64	59	54	49	45	41			
8+2	8.75			Load Coefficient→			1053	871	732	624	538	468	412	365	325	298	264	239	218	199	183	169	156	145	134
		4	50	2.00	1.60	1.34	203	180	161	145	131	119	108	99	91	83	76	70	65	60	55	51	47	44	40
		5	53	2.09	1.67	1.39	220	195	175	157	142	129	118	108	99	91	83	77	71	66	61	56	52	48	45
		6	56	2.17	1.74	1.45	235	208	187	168	152	138	126	115	106	97	89	83	76	71	65	60	56	52	48
8+2½	9.25			Load Coefficient→			1264	1045	878	748	645	562	494	438	390	350	316	287	262	239	220	202	187	174	161
		4	56	2.30	1.84	1.53	207	183	163	146	132	119	108	99	90	82	75	69	63	58	54	49	45	41	
		5	59	2.40	1.92	1.60	225	200	178	160	144	131	119	108	99	91	83	76	70	65	59	55	50	46	43
		6	62	2.49	1.99	1.66	242	214	192	172	155	141	128	117	107	98	90	83	76	70	65	60	55	51	47
				Load Coefficient→					990	845	728	634	557	493	440	395	366	323	295	270	248	228	211	196	182
10+2	10.75	4	56	2.17	1.73	1.45			207	187	170	154	142	130	119	110	102	94	88	81	76	70	65	61	57

				Load Coefficient→					1195	1017	877	765	672	595	530	476	430	390	356	325	298	275	254	236	220
10+2½	11.25	4	62	2.54	2.03	1.69			209	188	170	155	141	129	119	109	101	93	86	80	74	68	63	58	54
		5	66	2.64	2.12	1.76			227	205	186	168	154	141	130	119	110	101	94	87	81	75	69	64	60
		6	70	2.75	2.20	1.83			243	218	198	180	164	151	138	127	117	109	100	93	86	80	74	69	64
				Load Coefficient→					1388	1182	1020	888	780	691	616	554	499	453	413	378	347	320	296	274	255
10+3	11.75	4	68	2.86	2.28	1.90			212	190	172	156	142	130	119	109	100	92	85	78	72	66	61	56	52
		5	72	2.97	2.38	1.98			230	207	188	170	155	142	130	119	109	101	93	86	79	73	68	62	58
		6	76	3.09	2.47	2.06			247	222	201	183	167	152	140	128	118	109	100	93	86	79	73	68	62
				Load Coefficient→								801	705	623	556	499	450	408	372	341	313	288	266	247	230
12+2	12.75	5	66	2.38	1.91	1.59						206	189	174	160	148	138	128	119	111	104	97	91	85	79
		6	71	2.48	1.98	1.65						220	202	186	172	159	147	137	128	119	111	104	97	91	85
		7	75	2.57	2.06	1.72						233	214	197	182	168	156	145	135	126	118	110	103	96	90
		8	79	2.67	2.14	1.78						245	225	207	192	177	165	153	142	133	124	116	108	101	95
				Load Coefficient→								972	854	756	675	605	546	495	452	413	379	350	324	300	279
12+2½	13.25	5	73	2.82	2.25	1.88						206	189	173	160	147	137	126	117	109	101	95	88	82	76
		6	77	2.93	2.34	1.95						221	203	186	172	159	147	136	127	117	109	102	95	89	83
		7	81	3.04	2.43	2.03						235	215	198	183	169	156	145	134	125	116	109	101	94	88
		8	85	3.16	2.52	2.10						247	227	209	192	178	164	153	142	132	123	115	107	100	93
				Load Coefficient→								1130	995	880	785	705	636	577	526	481	441	407	376	349	325
12+3	13.75	5	79	3.19	2.55	2.13						207	190	174	160	147	136	126	116	108	100	93	86	80	74
		6	83	3.32	2.66	2.21						224	205	188	173	159	147	136	126	117	109	101	94	87	81
		7	87	3.45	2.76	2.30						238	217	200	184	169	157	145	134	125	116	108	100	93	87
		8	91	3.58	2.86	2.39						251	230	211	194	179	165	153	142	132	123	114	106	99	92
				Load Coefficient→											817	734	662	600	546	500	460	424	392	363	338
14+2½	15.25	5	80	2.92	2.34	1.95									191	176	164	152	141	132	123	115	107	100	94
		6	85	3.04	2.43	2.03									205	189	175	163	152	141	132	123	115	108	101
		7	90	3.16	2.53	2.11									217	201	186	173	161	150	140	131	122	114	107
		8	94	3.27	2.62	2.18									229	212	196	183	170	158	148	138	129	121	114
				Load Coefficient→											957	859	775	703	641	586	538	496	458	425	396
14+3	15.75	5	86	3.36	2.69	2.24									190	176	163	151	140	130	121	113	105	98	92
		6	91	3.49	2.79	2.33									205	189	175	162	151	140	131	122	113	106	99
		7	96	3.63	2.90	2.42									217	200	185	172	160	149	138	129	120	112	105
		8	100	3.76	3.01	2.51									229	212	196	182	170	158	147	137	128	120	112

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
Max. $v = 40$ p.s.i.
¾″ clear fireproofing

TABLE No. 11 — 30″ METAL PANS AND CONCRETE JOISTS (STRAIGHT PANS)

$$A_s = \frac{\textit{Total}\ \text{Load per sq. ft.}}{\text{Load Coeff.}} \times \text{Steel Coeff. (sq. in. per joist)}$$

Slab (Pan + Topping) Total Depth	Effective Depth	Width of Joist	Weight per Sq. Ft. Slab	Volume of Concrete Cu. Ft. per Sq. Ft.	STEEL COEFFICIENTS FOR MOMENTS OF			SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET															
In.	In.	In.	Lb.		$\frac{wl^2}{8}$	$\frac{wl^2}{10}$	$\frac{wl^2}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
					Load Coefficient→			824	681														
6+2½	7.25	4	41	0.27	2.75	2.20	1.84	31															
		5	43	0.29	2.83	2.27	1.89	44	36														
		6	45	0.30	2.92	2.33	1.94	56	47														
					Load Coefficient→			1264	1044	878	749	645	562										
8+2½	9.25	4	45	0.30	3.26	2.61	2.17	48	39														
		5	48	0.32	3.35	2.68	2.24	65	55	46	39												
		6	50	0.33	3.45	2.76	2.30	82	69	59	51	44	37										
					Load Coefficient→			1457	1204	1010	862	743	647										
8+3	9.75	4	51	0.34	3.60	2.88	2.40	46	37														
		5	54	0.36	3.71	2.97	2.47	64	53	44	36												
		6	56	0.37	3.81	3.05	2.54	81	69	58	49	42	35										
					Load Coefficient→			1720	1420	1194	1017	878	765	672	595	531							
10+2½	11.25	4	49	0.33	3.60	2.88	2.40	66	55	47	39												

					Load Coefficient→			1998	1650	1388	1182	1020	888	781	692								
10+3	11.75	4	56	0.37	4.04	3.23	2.69	62	51	43	35												
		5	59	0.39	4.16	3.33	2.77	85	72	61	52	43	37										
		6	61	0.41	4.28	3.43	2.86	107	92	79	68	59	51	44	38								
					Load Coefficient→			2186	1807	1519	1293	1115	972	855	756	675	605	547	495	452	414		
12+2½	13.25	5	57	0.38	3.94	3.15	2.63	109	94	82	71	62	54	47	41	35							
		6	61	0.40	4.05	3.24	2.70	133	115	100	88	77	68	60	53	47	41	36					
		7	64	0.43	4.16	3.33	2.78	156	136	119	105	93	83	73	65	58	52	46	41	36			
		8	67	0.45	4.27	3.42	2.85	178	156	137	121	108	96	86	77	69	62	55	49	44	39		
					Load Coefficient→			2543	2100	1767	1504	1298	1130	994	880	785	705	636	576	526	481		
12+3	13.75	5	63	0.42	4.47	3.58	2.98	108	92	79	68	59	50	43	37								
		6	67	0.45	4.60	3.68	3.07	132	114	99	86	75	66	57	50	43	38						
		7	70	0.47	4.73	3.78	3.15	156	135	118	104	91	80	71	63	55	49	43	37				
		8	73	0.49	4.85	3.88	3.24	179	155	136	120	106	94	84	75	66	59	52	46	41	36		
					Load Coefficient→			2648	2189	1838	1566	1351	1176	1034	916	817	734	662	600	546	500	460	424
14+2½	15.25	5	62	0.42	4.10	3.28	2.73	131	113	99	86	76	67	58	51	45	39						
		6	66	0.44	4.21	3.37	2.81	160	139	122	108	95	84	75	67	59	53	47	41	36			
		7	70	0.47	4.33	3.46	2.89	186	163	144	127	113	101	90	81	72	65	58	52	46	41	37	
		8	74	0.49	4.45	3.56	2.97	211	186	164	146	130	116	104	94	84	76	68	62	55	50	45	40
					Load Coefficient→			3100	2560	2150	1834	1580	1378	1210	1072	957	859	775	703	640	586	538	496
14+3	15.75	5	69	0.46	4.70	3.76	3.14	128	110	95	83	72	62	54	47	40	35						
		6	72	0.48	4.84	3.87	3.22	158	138	120	105	92	81	72	63	56	49	43	38				
		7	76	0.51	4.97	3.98	3.31	186	162	142	125	111	98	87	78	69	61	54	48	43	37		
		8	80	0.53	5.10	4.08	3.40	211	185	163	144	128	114	102	91	81	73	65	58	52	43	41	36

f_s = 20,000 p.s.i.
f_c = 800 p.s.i.
n = 15
Max. v = 40 p.s.i.
¾″ clear fireproofing

TABLE No. 12 — 30″ METAL PANS AND CONCRETE JOISTS (TAPERED PANS)

$A_s = \dfrac{\textit{Total}\text{ Load per sq. ft.}}{\text{Load Coeff.}} \times$ Steel Coeff. (sq. in. per joist)

Slab (Pan + Topping) Total Depth	Effective Depth	Width of Joist	Approx. Wt. Per Sq. Ft. of Slab	STEEL COEFFICIENTS FOR MOMENTS OF			SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET																		
In.	In.	In.	Lb.	$\frac{wl^2}{8}$	$\frac{wl^2}{10}$	$\frac{wl^2}{12}$	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
6+2½	7.25			Load Coefficient→			824	681	572	488	420	366	322	285	254	228									
		4	44	2.75	2.20	1.84	99	86	76	66	58	52	46	40											
		5	46	2.83	2.27	1.89	111	96	85	75	66	59	52	46	41										
		6	48	2.92	2.33	1.94	122	106	93	82	73	65	58	52	46	41									
8+2½	9.25			Load Coefficient→			1264	1044	878	749	645	562	494	438	390	350	316	287	262						
		4	49	3.26	2.61	2.17	137	120	106	94	84	75	67	60	54	49	44								
		5	52	3.35	2.68	2.24	151	132	117	104	93	83	75	67	61	55	49	45	40						
		6	54	3.45	2.76	2.30	166	145	129	115	103	92	83	75	68	61	56	50	46						
8+3	9.75			Load Coefficient→			1457	1204	1010	862	743	647	569	504	450	404	364	330	301	275					
		4	55	3.60	2.88	2.40	139	121	106	94	83	74	66	59	52	47	42								
		5	58	3.71	2.97	2.47	154	135	119	105	93	83	74	67	60	54	48	43							
		6	60	3.81	3.05	2.54	169	148	131	116	104	93	83	75	67	61	54	49	44	40					
10+2½	11.25			Load Coefficient→			1720	1420	1194	1017	878	765	672	595	531	476	430	390	356	325	298	275	254	236	
		4	53	3.60	2.88	2.40	176	155	138	123	111	100	90	82	74	68	61	56	51	47	43				

		5	56	3.70	2.96	2.47	194	172	153	137	123	111	101	91	83	76	69	63	58	53	48	44	40		
				Load	Coefficient	→	1998	1650	1388	1182	1020	888	781	692	616	554	499	453	413	378	347	320	296		
10+3	11.75	4	60	4.04	3.23	2.69	177	156	137	122	109	98	88	79	72	65	58	53	48	43					
		5	63	4.16	3.33	2.77	196	173	153	136	122	110	99	89	81	73	66	60	55	50	45	41			
		6	65	4.28	3.43	2.86	215	189	169	150	135	122	110	100	91	82	75	68	62	57	52	47	43		
				Load	Coefficient	→			1519	1293	1115	972	855	756	675	605	547	495	452	414	379	350	324	300	279
12+2½	13.25	5	61	3.94	3.15	2.63			188	169	153	138	126	115	105	96	88	81	75	69	63	59	54	50	46
		6	65	4.05	3.24	2.70			205	184	167	141	137	126	115	106	97	89	82	76	70	65	59	55	51
		7	68	4.16	3.33	2.78			221	198	180	163	148	136	125	114	105	97	90	83	76	71	65	60	56
		8	71	4.27	3.42	2.85			236	212	192	175	159	146	134	123	113	104	96	89	82	76	71	65	60
				Load	Coefficient	→			1767	1504	1298	1130	994	880	785	705	636	576	526	481	441	407	376	349	325
12+3	13.75	5	67	4.47	3.58	2.98			189	169	152	138	125	114	103	95	86	79	73	66	61	56	51	47	43
		6	71	4.60	3.68	3.07			206	184	166	151	137	124	114	104	95	87	80	73	67	62	57	52	47
		7	74	4.73	3.78	3.15			222	200	180	163	148	135	123	113	104	95	88	81	74	68	63	58	53
		8	77	4.85	3.88	3.24			237	213	193	175	159	145	133	122	112	103	95	87	80	74	68	63	58
				Load	Coefficient	→					1351	1176	1034	916	817	734	662	600	546	500	460	424	392	363	338
14+2½	15.25	5	66	4.10	3.28	2.73					183	166	152	139	127	117	108	100	92	85	79	73	68	63	58
		6	70	4.21	3.37	2.81					198	181	165	151	139	128	118	109	101	93	87	80	74	69	64
		7	74	4.33	3.46	2.89					214	194	178	163	150	138	127	118	109	101	94	87	81	75	70
		8	78	4.45	3.56	2.97					228	207	190	174	160	147	136	126	117	108	100	93	87	80	75
				Load	Coefficient	→					1580	1378	1210	1072	957	859	775	703	640	586	538	496	458	425	396
14+3	15.75	5	73	4.70	3.76	3.14					181	164	149	136	124	114	104	96	88	81	75	69	64	58	54
		6	76	4.84	3.87	3.22					198	180	164	150	138	126	116	107	99	91	84	78	72	66	61
		7	80	4.97	3.98	3.31					214	194	177	162	148	136	125	116	107	99	91	84	78	72	67
		8	84	5.10	4.08	3.40					228	208	189	173	159	146	135	124	115	106	98	91	84	78	72

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
1½" clear fireproofing

TABLE No. 13 — CONCRETE T-BEAMS

SIMPLE SPANS
$M = +\frac{1}{8}wl^2$

Total Depth of Beam In.	Effective Depth In.	Width of Web In.	Thickness of Flange In.	Weight of Web per Ft. Beam Lb.	Width of Flange In. *	Area of Steel Sq. In. *	Reinforcing Steel: Straight In.	Reinforcing Steel: Bent In. *	Design Coefficients: Reinf. Steel c_1 ($A_s = c_1 l$)	Design Coefficients: Flange Width c_2 ($b = c_2 l$) *	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
											SAFE SUPERIMPOSED LOADS IN LB. PER FT. OF BEAM — SPANS IN FEET (l)																			
12	10	8	4	67	30	2.27	1-1⅛ □	1-1 □	0.144	1.92	1330	1230	1130	1050	970	850	750	670	600	530	480									
		10	4	83	34	2.54	1-1⅛ □	1-1⅛ □	0.180	2.40	1670	1530	1420	1240	1080	950	830	740	660	590	530									
14	12	8	4	83	35	3.12	1-1¼ □	1-1¼ □	0.144	1.62	1600	1470	1360	1260	1180	1110	1040	980	930	880	820									
			4½	79	35				0.144	1.60	1600	1470	1360	1270	1180	1110	1040	980	930	880	820									
			5	75	35				0.144	1.60	1610	1480	1370	1270	1190	1110	1050	990	940	890	830									
		10	4	104	43	3.81	2-1⅛ □	1-1⅛ □	0.180	2.02	2000	1840	1700	1580	1480	1380	1300	1230	1160	1100	1000									
			4½	99	43				0.180	2.00	2000	1840	1700	1580	1480	1380	1300	1230	1160	1100	1000									
			5	94	43				0.180	2.00	2010	1840	1710	1590	1480	1390	1310	1230	1170	1110	1010									
		12	4	125	53	4.68	2-1¼ □	1-1¼ □	0.216	2.43	2400	2210	2040	1900	1770	1660	1560	1470	1390	1320	1230									
			4½	119	52				0.216	2.40	2400	2200	2040	1890	1770	1660	1560	1470	1390	1320	1240									
			5	113	52				0.216	2.40	2400	2210	2040	1900	1770	1660	1560	1480	1400	1330	1240									
16	14	8	4	100	31	3.12	1-1¼ □	1-1¼ □	0.144	1.45	1890	1730	1600	1490	1390	1300	1230	1160	1090	1040	960	870	790	730						
			5	92	30				0.144	1.38	1870	1720	1590	1480	1380	1290	1220	1150	1090	1030	960	870	790	730						
			6	83	30				0.144	1.37	1880	1720	1600	1480	1390	1300	1220	1150	1090	1040	970	880	800	740						
		10	4	125	38	3.81	2-1⅛ □	1-1⅛ □	0.180	1.82		2170	2000	1860	1740	1630	1530	1440	1370	1290	1180	1070	970	890						
			5	115	37				0.180	1.72		2150	1990	1850	1720	1610	1520	1430	1360	1290	1170	1060	970	880						
			6	104	37				0.180	1.71		2160	2000	1860	1730	1630	1530	1440	1370	1300	1180	1070	970	890						
		[illegible]	4	150	47	[illegible]	[illegible]	[illegible]	0.216	2.18		2600	2410	2240	2090	1960	1840	1730	1650	1550	1450	1310	1190	1090						
			[illegible]	[illegible]	[illegible]				[illegible]	[illegible]		2580	2380	2220	2070	1940	1820	1720	1630	1540	1440	1310	1190	1080						

18	16	8	4	117	29	3.12	1–1¼ □	1–1¼ □	0.144	1.35			1720	1600	1500	1410	1330	1260	1190	1110	1010	920	840	760	700	640			
			5	108	27				0.144	1.23			1700	1590	1490	1400	1320	1250	1180	1100	1000	910	830	760	700	640			
			6	100	26				0.144	1.20			1690	1580	1480	1390	1320	1250	1180	1110	1000	910	830	760	700	640			
			7	92	26				0.144	1.20			1700	1590	1490	1400	1330	1260	1190	1110	1010	920	840	770	710	650			
		10	4	146	35	3.81	2–1⅛ □	1–1⅛ □	0.180	1.69			2150	2000	1880	1770	1660	1570	1490	1350	1230	1110	1020	930	850	780			
			5	136	33				0.180	1.54			2120	1980	1850	1740	1640	1550	1490	1340	1220	1110	1010	920	840	780			
			6	125	32				0.180	1.50			2120	1980	1850	1740	1640	1560	1480	1350	1220	1110	1020	930	850	780			
			7	115	32				0.180	1.50			2130	1990	1860	1750	1650	1570	1490	1360	1230	1120	1030	940	860	790			
		12	4	175	43	4.68	2–1¼ □	1–1¼ □	0.216	2.02			2580	2400	2250	2120	2000	1890	1790	1670	1510	1370	1250	1140	1050	960			
			5	163	40				0.216	1.85			2540	2370	2230	2090	1970	1870	1770	1660	1500	1360	1250	1140	1040	960			
			6	150	39				0.216	1.80			2540	2370	2220	2090	1970	1870	1770	1650	1500	1370	1250	1140	1050	960			
			7	138	39				0.216	1.80			2550	2380	2230	2100	1980	1880	1780	1670	1510	1380	1260	1150	1060	980			
		14	4	204	57	6.24	2–1¼ □	2–1¼ □	0.252	2.36			3010	2810	2630	2470	2330	2200	2090	1980	1890	1800	1700	1550	1430	1310			
			5	190	53				0.252	2.16			2960	2770	2590	2440	2300	2180	2060	1960	1870	1780	1680	1540	1410	1300			
			6	175	52				0.252	2.10			2960	2760	2590	2440	2300	2180	2080	1960	1870	1780	1690	1550	1420	1310			
			7	161	52				0.252	2.10			2970	2780	2600	2450	2310	2190	2080	1980	1880	1800	1700	1560	1440	1320			
20	18	8	4	133	27	3.12	1–1¼ □	1–1¼ □	0.144	1.28			1950	1820	1710	1600	1510	1430	1350	1270	1150	1050	960	870	800	730	680	620	570
			5	125	25				0.144	1.14			1920	1790	1680	1580	1490	1410	1340	1250	1140	1030	940	860	790	730	670	620	570
			6	117	24				0.144	1.08			1900	1780	1670	1570	1480	1400	1330	1240	1120	1020	930	850	780	720	660	610	570
			7	108	23				0.144	1.07			1910	1780	1670	1570	1480	1400	1330	1250	1130	1030	940	860	790	730	670	620	580
		10	4	167	33	3.81	2–1⅛ □	1–1⅛ □	0.180	1.59			2440	2280	2130	2010	1890	1790	1690	1550	1400	1280	1160	1060	970	890	820	760	700
			5	156	30				0.180	1.43			2400	2240	2100	1980	1870	1760	1670	1520	1380	1250	1140	1040	960	880	810	750	690
			6	146	29				0.180	1.35			2380	2220	2080	1960	1850	1750	1660	1510	1370	1240	1130	1040	950	870	810	740	690
			7	135	29				0.180	1.33			2390	2230	2090	1970	1850	1760	1670	1520	1380	1250	1150	1050	960	890	820	750	700
		12	4	200	40	4.68	2–1¼ □	1–1¼ □	0.216	1.91			2930	2730	2560	2410	2270	2150	2030	1900	1720	1570	1430	1310	1200	1100	1010	930	860
			5	188	37				0.216	1.71			2880	2690	2520	2370	2230	2110	2000	1880	1700	1550	1410	1290	1180	1090	1000	920	850
			6	175	35				0.216	1.62			2860	2670	2500	2350	2220	2100	1990	1860	1690	1540	1400	1280	1180	1080	1000	920	850
			7	163	35				0.216	1.60			2860	2680	2510	2360	2230	2110	2000	1870	1700	1550	1410	1290	1190	1090	1010	930	860
		14	4	234	54	6.24	2–1¼ □	2–1¼ □	0.252	2.23			3410	3190	2980	2810	2650	2500	2370	2250	2150	2050	1940	1780	1630	1500	1380	1280	1180
			5	219	49				0.252	2.00			3360	3140	2940	2760	2610	2470	2340	2220	2120	2020	1910	1750	1610	1480	1360	1260	1160
			6	204	47				0.252	1.89			3330	3110	2910	2740	2590	2450	2320	2200	2090	2010	1890	1730	1590	1470	1350	1250	1160
			7	190	47				0.252	1.86			3340	3120	2930	2750	2600	2460	2330	2220	2110	2020	1910	1750	1610	1480	1370	1270	1170

*For all loadings to the right of the heavy zig-zag line, use the area of steel and width of flange shown in the table. Loads to the left of the heavy line are governed by shear (v = 120) and the areas of steel and the flange widths must be computed by means of the coefficients c_1 and c_2 as indicated.

$f_s = 20{,}000$ p.s.i. $n = 15$
$f_c = 800$ p.s.i. 1½" clear fireproofing

TABLE No. 13 Continued—CONCRETE T-BEAMS

SIMPLE SPANS
$M = +\frac{1}{8}wl^2$

Total Depth of Beam In.	Effective Depth In.	Width of Web In.	Thickness of Flange In.	Weight of Web per Ft. of Beam Lb.	Width of Flange* In.	Area of Steel* Sq. In.	Reinforcing Steel* (2 Layers) in Inches: Straight Bottom Layer	Bent Top Layer	Design Coefficients: Reinf. Steel c_1 ($A_s = c_1 l$)	Flange Width c_2 ($b = c_2 l$)	Safe Superimposed Loads in Lb. per Ft. of Beam — Spans in Feet (l): 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
22	18.88	8	4	150	35	4.00	2-1□	2-1□	0.144	1.252	2050	1910	1790	1680	1580	1500	1420	1350	1280	1220	1170	1120	1070	1020	940	870	800	740	690	640	600	560
			6	133	29				0.144	1.042	1990	1860	1740	1640	1550	1460	1390	1320	1250	1190	1140	1090	1050	1000	920	850	790	730	680	640	590	550
			8	117	28				0.144	1.017	2000	1860	1750	1640	1550	1470	1390	1320	1260	1200	1150	1100	1060	1010	930	870	800	750	690	650	600	560
		10	4	188	44	5.03	2-1⅛□	2-1⅛□	0.180	1.565	2550	2380	2230	2100	1980	1870	1770	1680	1600	1530	1460	1390	1340	1280	1190	1100	1020	950	880	820	760	710
			6	167	37				0.180	1.302	2490	2320	2170	2040	1930	1820	1730	1640	1560	1490	1420	1360	1310	1250	1170	1090	1010	930	870	810	750	700
			8	146	36				0.180	1.270	2490	2330	2180	2050	1940	1830	1740	1650	1570	1500	1440	1380	1320	1270	1190	1100	1020	950	880	820	770	720
		12	4	225	55	6.32	4-1φ	4-1φ	0.216	1.880	3070	2860	2690	2520	2380	2250	2130	2020	1930	1840	1750	1680	1610	1540	1480	1380	1280	1190	1100	1030	960	890
			6	200	46				0.216	1.562	2990	2790	2610	2460	2320	2190	2080	1970	1880	1790	1710	1640	1570	1510	1450	1360	1260	1170	1090	1010	940	880
			8	175	45				0.216	1.524	2990	2800	2620	2470	2330	2200	2090	1990	1890	1810	1730	1650	1590	1520	1460	1380	1280	1190	1110	1030	960	900
		14	4	263	62	7.16	4-1□	4-1φ	0.252	2.195	3580	3340	3130	2940	2770	2620	2480	2360	2240	2140	2040	1950	1870	1800	1680	1560	1440	1330	1240	1150	1070	1000
			6	234	52				0.252	1.823	3480	3250	3050	2870	2700	2550	2420	2300	2190	2090	2000	1910	1830	1760	1660	1530	1420	1320	1230	1140	1060	990
			8	204	51				0.252	1.780	3500	3270	3050	2880	2720	2570	2440	2320	2210	2110	2020	1930	1850	1780	1670	1550	1440	1340	1250	1160	1090	1020
		16	4	300	78	8.95	5-1□	5-1φ	0.288	2.505	4090	3810	3570	3360	3170	2990	2840	2690	2560	2440	2330	2230	2140	2050	1970	1890	1820	1700	1580	1470	1370	1280
			6	267	65				0.288	2.085	3980	3720	3480	3270	3090	2920	2770	2630	2500	2390	2280	2190	2090	2010	1930	1860	1790	1670	1550	1450	1350	1260
			8	234	63				0.288	2.035	3990	3730	3500	3290	3100	2940	2790	2650	2530	2410	2300	2210	2120	2030	1950	1880	1810	1690	1580	1480	1380	1290
24	20.88	10	4	208	47	5.66	2-1¼□	2-1⅛□	0.180	1.508	2850	2660	2490	2340	2210	2090	1980	1880	1790	1700	1630	1560	1490	1430	1370	1320	1270	1190	1110	1030	960	900
			6	188	38				0.180	1.215	2770	2590	2420	2280	2150	2030	1930	1830	1740	1660	1590	1520	1460	1400	1340	1290	1240	1170	1090	1020	950	890
			8	167	36				0.180	1.150	2750	2570	2410	2260	2140	2020	1920	1820	1740	1660	1580	1520	1450	1400	1340	1290	1250	1180	1100	1030	960	900
		12	4	250	60	7.16	4-1□	4-1φ	0.216	1.810	3420	3190	2990	2810	2650	2500	2370	2250	2140	2040	1950	1870	1790	1710	1650	1580	1520	1470	1420	1320	1230	1150
			6	225	48				0.216	1.458	3330	3110	2910	2740	2580	2440	2320	2200	2090	2000	1910	1830	1750	1680	1610	1550	1500	1440	1390	1310	1220	1140
			8	200	46				0.216	1.380	3300	3080	2890	2720	2560	2430	2300	2190	2080	1990	1900	1820	1740	1670	1610	1550	1490	1440	1390	1310	1220	1150
		14	4	292	67	8.00	4-1□	4-1□	0.252	2.113	3990	3720	3490	3280	3090	2920	2770	2630	2500	2390	2280	2180	2090	2000	1930	1850	1780	1690	1570	1460	1360	1270
			6	263	54				0.252	1.701	3890	3530	3400	3200	3010	2850	2700	2570	2450	2330	2230	2130	2040	1960	1890	1810	1750	1660	1550	1440	1350	1260
			8	234	51				0.252	1.610	3860	3610	3380	3180	3000	2840	2690	2560	2440	2330	2220	2130	2040	1960	1880	1810	1750	1670	1560	1460	1360	1270
		16	4	333	80	10.00	5-1□	5-1□	0.288	2.414	4570	4270	3990	3750	3540	3340	3170	3010	2860	2730	2610	2490	2390	2290	2200	2120	2040	1960	1900	1830	1650	1540
			6	300	68				0.288	1.944	4440	4150	3890	3650	3450	3260	3090	2930	2790	2670	2550	2440	2340	2240	2150	2070	2000	1920	1860	1790	1710	1600
			8	267	64				0.288	1.840	4410	4120	3860	3630	3420	3240	3070	2920	2780	2660	2540	2430	2330	2240	2150	2070	1990	1920	1860	1790	1720	1620
26	22.88	10	4	229					0.180	1.464	3140	2930	2740	2580	2430	2300	2180	2070	1970	1870	1790	1710	1640	1570	1510	1450	1400	1350	1300	1260	1210	1170
			6	208					0.180	1.152	3050	2850	2670	2510	2370	2240	2120	2010	1920	1830	1750	1670	1600	1540	1480	1420	1370	1320	1270	1230	1190	1150
			8	188					0.180	1.054	3010	2810	2640	2480	2340	2210	2100	1990	1900	1810	1730	1660	1590	1530	1470	1410	1360	1310	1270	1220	1180	1150
			10	167					0.180	1.050	3030	2830	2660	2500	2360	2230	2120	2010	1920	1830	1750	1680	1610	1550	1490	1430	1380	1330	1290	1240	1200	1170
		12	4	275					0.216	1.758	3770	3520	3290	3100	2920	2760	2620	2490	2360	2250	2150	2060	1970	1890	1820	1750	1680	1620	1560	1510	1460	1410
			6	250					0.216	1.382	3670	3420	3210	3010	2840	2690	2550	2420	2300	2200	2100	2010	1930	1850	1770	1710	1650	1580	1530	1480	1430	1380
			8	225					0.216	1.266	3620	3380	3170	2980	2810	2650	2520	2400	2280	2180	2080	1990	1910	1840	1760	1700	1640	1580	1520	1470	1420	1380
			10	200					0.216	1.260	3640	3400	3190	3000	2840	2680	2540	2420	2310	2200	2110	2020	1940	1860	1790	1720	1660	1600	1550	1500	1450	1400
		14	4	321					0.252	2.050	4390	4100	3840	3610	3400	3220	3040	2890	2750	2630	2510	2400	2300	2200	2120	2040	1960	1890	1820	1760	1700	1640
			6	292					0.252	1.612	4270	3990	3740	3520	3310	3130	2970	2820	2690	2560	2450	2340	2240	2150	2070	1990	1920	1850	1780	1720	1670	1610
			8	263					0.252	1.477	4220	3940	3690	3480	3280	3100	2940	2800	2660	2540	2430	2320	2230	2140	2060	1980	1910	1840	1770	1720	1660	1610
			10	234					0.252	1.468	4250	3970	3720	3510	3310	3130	2970	2830	2690	2570	2460	2350	2260	2170	2090	2010	1940	1870	1800	1740	1690	1630
		16	4	367					0.288	2.345	5030	4680	4390	4130	3890	3680	3480	3310	3150	3000	2870	2740	2630	2520	2420	2330	2240	2160	2080	2010	1940	1880
			6	333					0.288	1.844	4890	4560	4270	4020	3790	3580	3390	3230	3070	2930	2800	2680	2570	2460	2370	2280	2190	2110	2040	1970	1900	1840
			8	300					0.288	1.690	4830	4500	4220	3980	3750	3550	3360	3200	3050	2910	2780	2660	2550	2450	2350	2260	2180	2100	2030	1960	1900	1840
			10	267					0.288	1.680	4850	4530	4250	4010	3780	3580	3390	3230	3080	2940	2810	2690	2580	2480	2380	2290	2210	2130	2060	1990	1930	1870

*For all loadings to the right of the heavy zig-zag line, use the area of steel and width of flange shown in the table. Loads to the left of the heavy line are governed by shear ($v = 120$) and the areas of steel and the flange widths must be computed by means of the coefficients c_1 and c_2 as indicated.

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
1½" clear fireproofing

TABLE No. 13 Continued—CONCRETE T-BEAMS

SIMPLE SPANS
$M = +\frac{1}{8}wl^2$

Total Depth of Beam	Effective Depth	Width of Web	Thickness of Flange	Weight of Web per Ft. of Beam	Design Coefficients: Reinf. Steel c_1 ($A_s = c_1 l$)	Design Coefficients: Flange Width c_2 ($b = c_2 l$)	SAFE SUPERIMPOSED LOADS IN LB. PER FT. OF BEAM — SPANS IN FEET (l): 15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
In.	In.	In.	In.	Lb.																								
28	24.75	10	6	229	0.180	1.105	3330	3100	2910	2730	2580	2440	2310	2190	2090	1990	1910	1820	1750	1670	1610	1550	1490	1440	1390	1340	1290	1250
			8	208	0.180	0.990	3270	3060	2860	2690	2540	2400	2280	2170	2060	1970	1880	1800	1730	1660	1590	1530	1480	1420	1370	1330	1280	1240
			10	188	0.180	0.970	3280	3060	2870	2700	2550	2410	2290	2180	2070	1980	1890	1810	1740	1670	1600	1550	1490	1440	1390	1340	1300	1260
		12	6	275	0.216	1.325	3990	3730	3490	3280	3100	2930	2780	2640	2510	2390	2290	2190	2100	2010	1930	1860	1790	1730	1670	1610	1550	1500
			8	250	0.216	1.188	3930	3670	3430	3230	3050	2880	2730	2600	2470	2360	2250	2160	2070	1990	1910	1840	1770	1710	1650	1590	1540	1490
			10	225	0.216	1.163	3940	3680	3450	3240	3060	2900	2750	2610	2490	2380	2270	2180	2090	2000	1930	1860	1790	1730	1670	1610	1560	1510
		14	6	321	0.252	1.547	4660	4350	4080	3830	3610	3400	3240	3080	2930	2790	2670	2550	2450	2350	2260	2170	2090	2010	1940	1880	1810	1760
			8	292	0.252	1.386	4570	4270	4010	3760	3550	3360	3190	3030	2880	2750	2630	2520	2410	2320	2230	2140	2060	1990	1920	1860	1780	1730
			10	263	0.252	1.358	4590	4290	4020	3780	3570	3370	3200	3040	2900	2770	2650	2540	2430	2340	2240	2160	2080	2010	1940	1890	1820	1760
		16	6	367	0.288	1.768	5320	4970	4650	4380	4130	3900	3700	3510	3340	3190	3050	2920	2800	2680	2580	2480	2390	2300	2220	2140	2070	2000
			8	333	0.288	1.583	5230	4880	4580	4310	4060	3840	3640	3460	3300	3150	3010	2880	2760	2650	2550	2450	2360	2280	2200	2120	2050	1990
			10	300	0.288	1.550	5240	4900	4590	4320	4070	3850	3660	3480	3310	3160	3020	2900	2780	2670	2570	2470	2380	2300	2220	2150	2080	1910
		18	6	413	0.324	1.990	5990	5590	5240	4920	4640	4390	4160	3950	3760	3590	3430	3280	3140	3010	2900	2790	2680	2590	2500	2410	2330	2250
			8	375	0.324	1.780	5890	5500	5160	4850	4580	4330	4100	3900	3710	3540	3390	3240	3110	2980	2870	2760	2660	2560	2480	2390	2310	2240
			10	338	0.324	1.745	5900	5510	5160	4860	4580	4340	4110	3910	3730	3560	3400	3260	3120	3000	2890	2780	2680	2580	2500	2410	2330	2260
30	26.75	10	6	250	0.180	1.070	3620	3380	3160	2970	2810	2650	2510	2390	2270	2170	2070	1980	1900	1820	1750	1680	1620	1560	1510	1460	1410	1360
			8	229	0.180	0.936	3550	3320	3110	2920	2760	2610	2470	2350	2240	2130	2040	1950	1870	1800	1730	1660	1600	1540	1490	1440	1390	1350
			10	208	0.180	0.899	3540	3310	3100	2920	2750	2600	2470	2350	2240	2140	2040	1950	1870	1800	1730	1670	1610	1550	1500	1440	1400	1350
			12	188	0.180	0.899	3560	3330	3120	2940	2770	2620	2490	2370	2260	2160	2060	1970	1890	1820	1750	1690	1630	1570	1520	1460	1420	1370
		12	6	300	0.216	1.282	4340	4050	3800	3570	3360	3180	3020	2870	2730	2600	2490	2380	2280	2190	2100	2020	1950	1880	1810	1750	1690	1630
			8	275	0.216	1.123	4270	3980	3730	3510	3310	3130	2970	2820	2690	2560	2450	2340	2250	2150	2070	1990	1920	1850	1790	1730	1670	1620
			10	250	0.216	1.078	4250	3970	3720	3500	3310	3130	2970	2820	2690	2560	2450	2350	2250	2160	2080	2000	1930	1860	1800	1740	1680	1630
			12	225	0.216	1.078	4280	4000	3750	3530	3330	3150	2990	2850	2710	2590	2480	2380	2280	2190	2100	2030	1960	1890	1820	1760	1710	1650
		14	6	350	0.252	1.496	5060	4730	4430	4160	3930	3710	3520	3340	3180	3030	2900	2770	2660	2550	2450	2360	2270	2190	2110	2040	1970	1910
			8	321	0.252	1.310	4970	4640	4350	4090	3850	3650	3460	3290	3130	2990	2850	2730	2620	2510	2420	2320	2240	2160	2080	2010	1950	1880
			10	292	0.252	1.257	4960	4630	4340	4080	3850	3640	3460	3290	3130	2990	2860	2740	2620	2520	2420	2330	2250	2170	2090	2020	1960	1890
			12	263	0.252	1.257	4990	4660	4320	4110	3880	3670	3490	3320	3160	3020	2890	2770	2650	2550	2450	2360	2280	2200	2120	2050	1990	1920
		16	6	400	0.288	1.710	5790	5400	5060	4760	4490	4240	4020	3820	3640	3470	3310	3170	3040	2910	2800	2690	2590	2500	2410	2330	2250	2180
			8	367	0.288	1.498	5680	5300	4970	4670	4410	4170	3950	3760	3580	3410	3260	3120	2990	2870	2760	2660	2560	2470	2380	2300	2230	2150
			10	333	0.288	1.438	5670	5290	4970	4670	4410	4170	3950	3760	3580	3420	3270	3130	3000	2880	2770	2670	2570	2480	2390	2310	2240	2170
			12	300	0.288	1.438	5700	5320	5000	4700	4440	4200	3990	3790	3610	3450	3300	3160	3030	2910	2800	2700	2600	2510	2430	2350	2270	2200
		18	6	450	0.324	1.923	6500	6080	5700	5350	5050	4770	4520	4300	4090	3900	3730	3570	3420	3280	3150	3030	2920	2810	2720	2620	2540	2450
			8	413	0.324	1.684	6390	5970	5590	5260	4960	4690	4450	4230	4030	3840	3670	3510	3370	3230	3110	2990	2880	2780	2680	2590	2500	2420
			10	375	0.324	1.616	6370	5950	5580	5250	4950	4680	4450	4230	4030	3850	3680	3520	3380	3240	3120	3000	2890	2790	2690	2600	2520	2440
			12	338	0.324	1.616	6400	5990	5610	5280	4990	4720	4480	4260	4060	3880	3710	3560	3410	3280	3150	3030	2920	2820	2730	2640	2550	2470

$f_s = 20{,}000$ p.s.i.
$f_c = 900$ p.s.i.
$n = 15$

TABLE No. 14 — CONCRETE T-BEAMS

TWO SPANS
$M = -\frac{1}{8}wl^2$
at center support

Total Depth of Beam In.	Effective Depth In.	Width of Web In.	Weight per Foot of Beam Lb.	Required Area of Steel Sq. In.	Reinforcing Steel Straight In.	Reinforcing Steel Bent In.	c_1 ($A_s = c_1 l$)*	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
								SAFE SUPERIMPOSED LOADS IN LB. PER FT. OF BEAM — SPANS IN FEET (l)																			
12	10	6	75	0.55	1-⅝ϕ	1-⅝ϕ	0.108	1670	1210	910	700	550	450	360	300	250	210	170	140	120							
		8	100	0.73	1-⅝ϕ	1-¾ϕ	0.144	2230	1610	1210	940	740	590	480	400	330	270	230	190	160							
		10	125	0.91	1-¾ϕ	1-¾ϕ	0.180	2790	2020	1510	1170	920	740	600	500	410	340	290	240	200							
14	12	8	117	0.87	1-¾ϕ	1-¾ϕ	0.144	3230	2340	1770	1370	1090	880	720	600	500	420	350	300	260	220	190	160				
		10	146	1.09	1-¾ϕ	1-⅞ϕ	0.180	4040	2930	2210	1720	1360	1100	900	750	620	530	440	380	320	270	230	200				
		12	175	1.31	1-⅞ϕ	1-1ϕ	0.216	4850	3520	2650	2060	1640	1320	1080	900	750	630	530	450	380	330	280	240				
16	14	8	133	1.02	1-¾ϕ	1-⅞ϕ	0.144	3750	3210	2430	1890	1510	1220	1010	840	700	600	510	430	370	320	280	240				
		10	167	1.27	1-⅞ϕ	1-1ϕ	0.180	4680	4010	3030	2360	1890	1530	1260	1050	880	750	640	540	470	400	350	300				
		12	200	1.53	1-1ϕ	1-1ϕ	0.216	5620	4820	3640	2830	2260	1830	1510	1250	1060	890	760	650	560	480	420	360				
18	16	8	150	1.16	1-⅞ϕ	1-⅞ϕ	0.144	4280	3650	3200	2500	2000	1620	1340	1120	940	810	690	590	510	450	390	340				
		10	188	1.46	1-1ϕ	1-1ϕ	0.180	5360	4560	4000	3120	2490	2020	1670	1400	1180	1000	860	740	640	560	480	420				
		12	225	1.75	2-¾ϕ	2-¾ϕ	0.216	6430	5480	4810	3750	3000	2440	2010	1680	1420	1210	1030	890	770	670	580	510				
		14	262	2.04	2-¾ϕ	2-⅞ϕ	0.252	7510	6390	5590	4360	3490	2840	2340	1960	1650	1400	1200	1040	900	780	680	590				
20	18	8	167	1.31	1-⅞ϕ	1-1ϕ	0.144	4820	4100	3570	3180	2550	2070	1720	1440	1220	1040	890	770	670	590	510	450				
		10	208	1.64	2-¾ϕ	2-¾ϕ	0.180	6020	5130	4460	3980	3190	2600	2150	1800	1530	1300	1120	970	840	740	640	560				
		12	250	1.97	2-¾ϕ	2-⅞ϕ	0.216	7230	6150	5350	4780	3830	3120	2580	2160	1830	1560	1340	1160	1010	880	770	670				
		14	292	2.29	2-⅞ϕ	2-⅞ϕ	0.252	8440	7180	6260	5560	4460	3630	3010	2520	2130	1820	1560	1350	1170	1020	900	790				
22	20	10	229	1.82	1-1□	1-1□	0.180					3930	3230	2680	2250	1910	1630	1410	1220	1060	930	820	720	640	560	500	440
		12	275	2.18	2-⅞ϕ	2-⅞ϕ	0.216					4720	3880	3220	2700	2290	1960	1690	1470	1280	1120	980	870	770	680	600	530
		14	321	2.55	2-⅞ϕ	2-1ϕ	0.252					5500	4530	3760	3150	2670	2290	1970	1710	1490	1310	1150	1010	890	790	700	620
		16	367	2.91	2-1ϕ	2-1ϕ	0.288					6290	5170	4280	3590	3050	2610	2250	1950	1700	1490	1310	1150	1020	900	800	700
24	22	10	250	2.00	1-1□	1-1□	0.180					4330	3910	3270	2750	2340	2010	1730	1510	1320	1160	1020	900	800	710	630	560
		12	300	2.40	2-⅞ϕ	2-⅞ϕ	0.216					5190	4690	3920	3290	2800	2400	2080	1800	1580	1380	1220	1080	960	850	750	670
		14	350	2.80	2-⅞ϕ	2-1ϕ	0.252					6050	5480	4580	3850	3270	2810	2420	2110	1840	1620	1430	1260	1120	990	880	790
		16	400	3.20	2-1ϕ	2-1ϕ	0.288					6920	6260	5250	4400	3750	3210	2780	2410	2110	1850	1630	1440	1280	1140	1010	900
26	24	10	271	2.18	1-1ϕ	2-1ϕ	0.180					4720	4260	3880	3300	2810	2410	2090	1820	1590	1400	1240	1100	980	870	780	690
		12	325	2.62	2-⅞ϕ	2-1ϕ	0.216					5670	5130	4670	3970	3380	2900	2510	2190	1920	1690	1490	1320	1180	1050	930	840
		14	379	3.06	2-1ϕ	2-1ϕ	0.252					6610	5970	5440	4620	3930	3380	2920	2540	2230	1960	1730	1530	1370	1220	1090	970
		16	433	3.49	2-1ϕ	2-1□	0.288					7560	6830	6220	5280	4500	3860	3340	2910	2550	2250	1980	1760	1570	1390	1250	1110
28	26	12	350	2.84	2-1ϕ	2-1ϕ	0.216					6140	5550	5050	4640	4000	3440	2980	2600	2280	2010	1780	1580	1410	1260	1130	1010
		14	408	3.31	2-1ϕ	2-1□	0.252					7160	6480	5900	5410	4650	4000	3460	3020	2650	2340	2070	1840	1640	1470	1310	1180
		16	467	3.78	2-1□	2-1□	0.288					8180	7390	6730	6180	5320	4570	3960	3450	3030	2670	2360	2100	1880	1680	1500	1350
		18	525	4.26	3-⅞ϕ	4-⅞ϕ	0.324					9210	8330	7590	6960	5980	5140	4450	3890	3410	3010	2660	2370	2110	1890	1690	1520
30	28	12	375	3.06	2-1ϕ	2-1ϕ	0.216							5450	5000	4630	4010	3480	3040	2670	2360	2090	1860	1670	1490	1340	1200
		14	437	3.57	2-1ϕ	2-1□	0.252							6350	5820	5380	4670	4050	3540	3110	2750	2440	2170	1940	1740	1560	1400
		16	500	4.08	3-⅞ϕ	3-1ϕ	0.288							7270	6670	6150	5340	4630	4050	3560	3140	2790	2480	2220	1990	1780	1600
		18	563	4.59	3-1ϕ	3-1ϕ	0.324							8170	7500	6930	6010	5210	4550	4000	3530	3130	2790	2490	2230	2000	1800
		20	625	5.10	3-1ϕ	4-1ϕ	0.360							9080	8330	7680	6680	5790	5060	4450	3930	3480	3100	2770	2480	2230	2010

*For all loadings to the right of the heavy zig-zag line, use the area of steel shown in the table. Loads to the left of the heavy line are governed by shear (v=120) and the areas of steel must be computed by means of the coefficient c_1 as indicated.

TABLE No. 15 — CONCRETE T-BEAMS

$f_s = 20{,}000$ p.s.i.
$f_c = 900$ p.s.i.
$n = 15$

END SPANS (More than 2 spans)

$M = \frac{1}{10} wl^2$

Total Depth of Beam	Effective Depth	Width of Web	Weight per Foot of Beam	Required Area of Steel	Reinforcing Steel		*	SAFE SUPERIMPOSED LOADS IN LB. PER FT. OF BEAM — SPANS IN FEET (l)																			
					Straight	Bent	c_1 ($A_s = c_1 l$)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
In.	In.	In.	Lb.	Sq. In.	In.	In.																					
12	10	6	75	0.55	1-5/8φ	1-5/8φ	0.086	2010	1530	1150	900	710	580	470	390	330	270	230	200	170							
		8	100	0.73	1-5/8φ	1-3/4φ	0.115	2670	2040	1540	1190	950	770	630	520	440	370	310	260	220							
		10	125	0.91	1-3/4φ	1-3/4φ	0.144	3340	2570	1920	1490	1190	960	790	650	540	460	390	330	280							
14	12	8	117	0.87	1-3/4φ	1-3/4φ	0.115	3210	2740	2240	1750	1390	1130	930	780	650	550	470	410	350	300	260	230				
		10	146	1.09	1-3/4φ	1-7/8φ	0.144	4010	3410	2800	2180	1740	1410	1160	970	820	690	590	510	440	380	330	280				
		12	175	1.31	1-7/8φ	1-1φ	0.173	4820	4100	3360	2620	2090	1690	1400	1160	980	830	710	610	520	450	390	340				
16	14	8	133	1.02	1-3/4φ	1-7/8φ	0.115	3750	3200	2780	2400	1920	1570	1290	1080	920	780	670	580	500	440	380	330				
		10	167	1.27	1-7/8φ	1-1φ	0.144	4680	3990	3470	3000	2400	1950	1620	1350	1140	970	840	720	630	550	480	420				
		12	200	1.53	1-1φ	1-1φ	0.173	5620	4790	4170	3600	2880	2350	1940	1620	1370	1170	1000	870	750	650	570	500				
18	16	8	150	1.16	1-7/8φ	1-7/8φ	0.115	4280	3650	3170	2810	2540	2070	1720	1440	1220	1040	900	780	680	590	520	460				
		10	188	1.46	1-1φ	1-1φ	0.144	5360	4560	3970	3510	3160	2580	2140	1790	1520	1300	1120	970	850	740	650	570				
		12	225	1.75	2-3/4φ	2-3/4φ	0.173	6430	5480	4770	4220	3800	3100	2570	2160	1830	1560	1350	1170	1020	890	780	690				
		14	262	2.04	2-3/4φ	2-7/8φ	0.202	7510	6390	5560	4920	4430	3610	2990	2510	2130	1820	1570	1360	1190	1040	910	800				
20	18	8	167	1.31	1-7/8φ	1-1φ	0.115	4820	4100	3570	3160	2830	2550	2190	1840	1560	1340	1160	1010	880	770	680	600				
		10	208	1.64	2-3/4φ	2-3/4φ	0.144	6020	5130	4460	3950	3530	3190	2730	2300	1950	1680	1450	1260	1100	970	850	750				
		12	250	1.97	2-3/4φ	2-7/8φ	0.173	7230	6150	5350	4740	4240	3840	3290	2770	2350	2020	1740	1510	1320	1160	1030	910				
		14	292	2.29	2-7/8φ	2-7/8φ	0.202	8440	7180	6260	5530	4950	4470	3840	3230	2750	2350	2030	1770	1540	1360	1200	1060				
22	20	10	229	1.82	1-1□	1-1□	0.144					3930	3560	3240	2870	2440	2100	1820	1580	1390	1220	1080	960	850	760	680	610
		12	275	2.18	2-7/8φ	2-7/8φ	0.173					4720	4270	3890	3450	2940	2520	2180	1900	1670	1470	1300	1150	1030	910	820	730
		14	321	2.55	2-7/8φ	2-1φ	0.202					5500	4980	4540	4020	3420	2940	2540	2220	1940	1710	1510	1340	1200	1070	950	850
		16	367	2.91	2-1φ	2-1φ	0.230					6290	5680	5180	4590	3910	3360	2910	2530	2220	1950	1730	1530	1370	1220	1090	970
24	22	10	250	2.00	1-1□	1-1□	0.144					4330	3910	3570	3270	2990	2570	2230	1940	1710	1510	1330	1190	1060	950	850	760
		12	300	2.40	2-7/8φ	2-7/8φ	0.173					5190	4690	4280	3920	3580	3080	2670	2330	2050	1810	1600	1420	1270	1140	1020	920
		14	350	2.80	2-7/8φ	2-1φ	0.202					6050	5480	4990	4570	4180	3590	3120	2720	2390	2110	1870	1660	1480	1330	1190	1070
		16	400	3.20	2-1φ	2-1φ	0.230					6920	6260	5700	5240	4780	4110	3570	3120	2740	2410	2140	1900	1700	1520	1360	1220
26	24	10	271	2.18	1-1φ	2-1φ	0.144					4720	4270	3880	3570	3290	3050	2680	2340	2060	1820	1610	1440	1290	1160	1040	940
		12	325	2.62	2-7/8φ	2-1φ	0.173					5670	5130	4670	4290	3960	3670	3210	2810	2470	2180	1940	1730	1550	1390	1250	1120
		14	379	3.06	2-1φ	2-1φ	0.202					6610	5970	5440	5000	4610	4280	3740	3270	2880	2540	2260	2010	1800	1620	1450	1310
		16	433	3.49	2-1φ	2-1□	0.230					7560	6830	6220	5720	5270	4890	4290	3750	3300	2920	2590	2310	2070	1850	1670	1500
28	26	12	350	2.84	2-1φ	2-1φ	0.173					6140	5550	5050	4640	4290	3980	3710	3330	2940	2600	2310	2060	1850	1660	1500	1350
		14	408	3.31	2-1φ	2-1□	0.202					7160	6480	5900	5410	5000	4640	4320	3880	3420	3030	2690	2400	2160	1940	1750	1580
		16	467	3.78	2-1□	2-1□	0.230					8180	7390	6730	6180	5710	5290	4940	4430	3900	3450	3070	2740	2460	2210	1960	1800
		18	525	4.26	3-7/8φ	4-7/8φ	0.259					9210	8330	7590	6960	6430	5960	5550	4990	4390	3890	3500	3090	2770	2490	2240	2030
30	28	12	375	3.06	2-1φ	2-1φ	0.173							5450	5000	4630	4290	4000	3740	3430	3040	2710	2420	2170	1960	1770	1600
		14	437	3.57	2-1φ	2-1□	0.202							6350	5820	5380	5000	4650	4360	4010	3550	3160	2820	2540	2280	2060	1870
		16	500	4.08	3-7/8φ	3-1φ	0.230							7270	6670	6150	5710	5330	4990	4570	4050	3600	3220	2900	2610	2350	2130
		18	563	4.59	3-1φ	3-1φ	0.259							8170	7500	6920	6420	5990	5600	5140	4560	4060	3630	3260	2930	2650	2400
		20	625	5.10	3-1φ	4-1φ	0.288							9080	8330	7700	7130	6650	6220	5720	5070	4510	4030	3620	3260	2940	2660

*For all loadings to the right of the heavy zig-zag line, use the area of steel shown in the table. Loads to the left of the heavy line are governed by shear ($v = 120$) and the areas of steel must be computed by means of the coefficient c_1 as indicated.

$f_s = 20{,}000$ p.s.i.
$f_c = 900$ p.s.i.
$n = 15$

TABLE No. 16—CONCRETE T-BEAMS

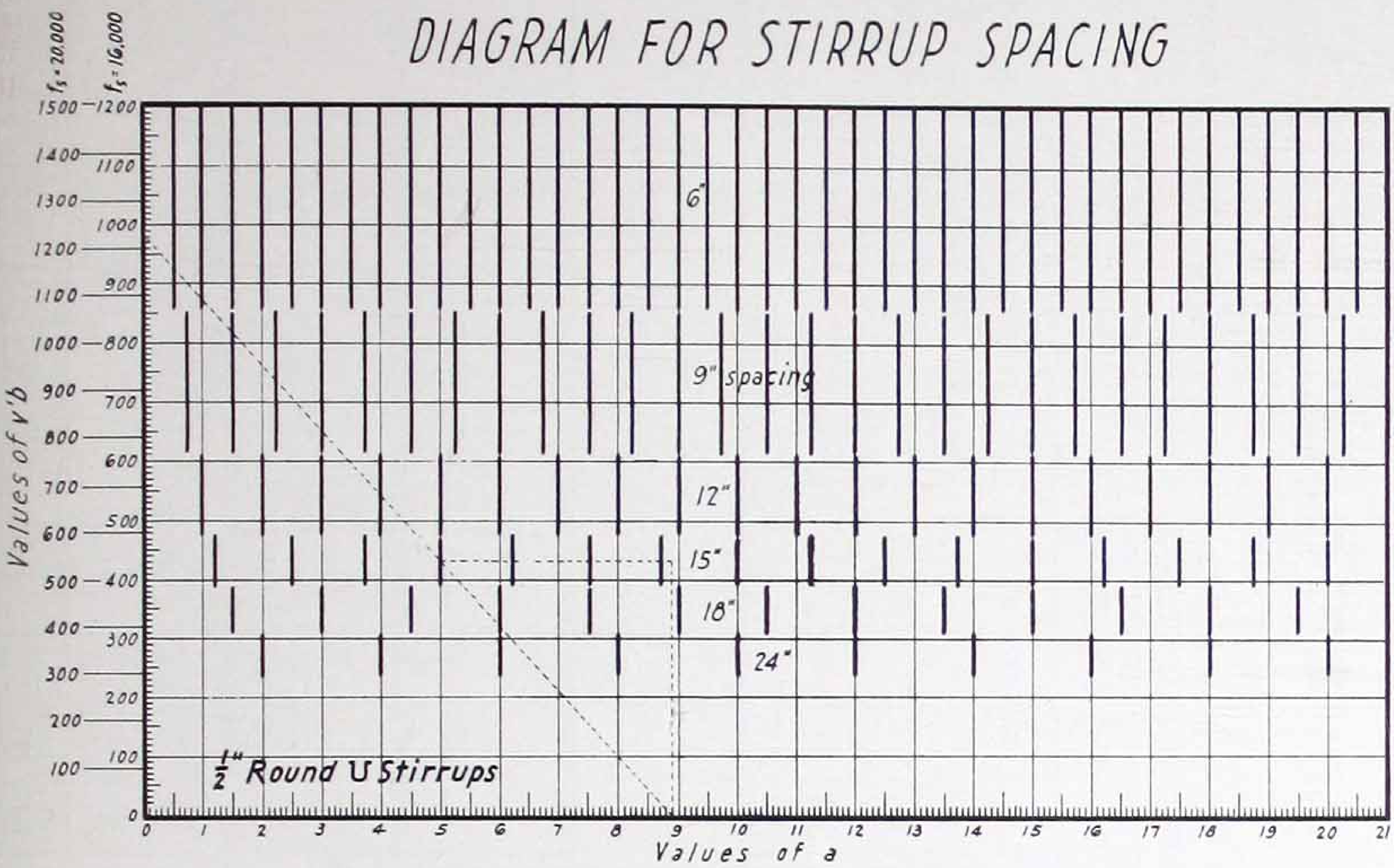
INTERIOR SPANS

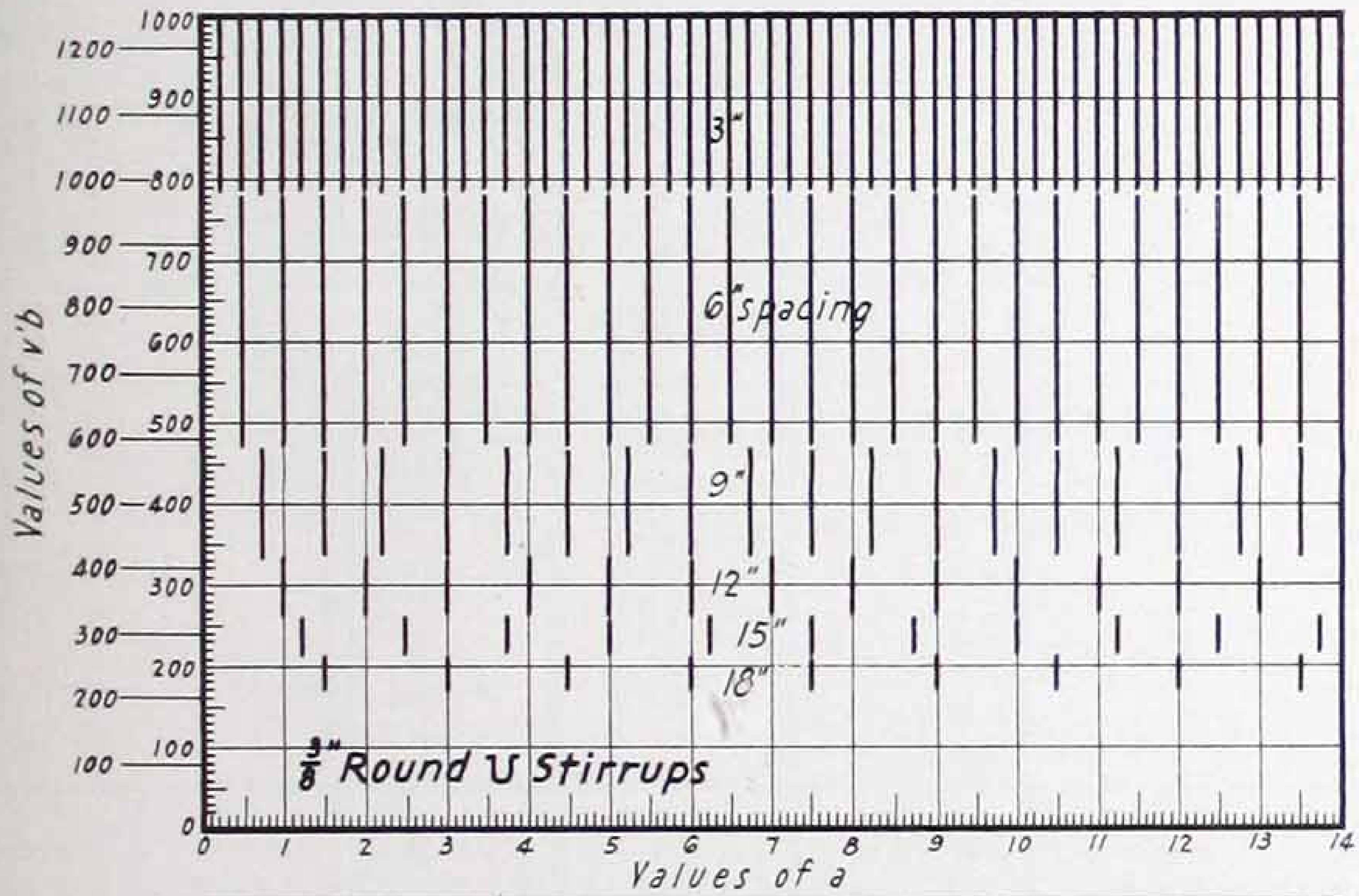
$M = \frac{1}{12} w l^2$

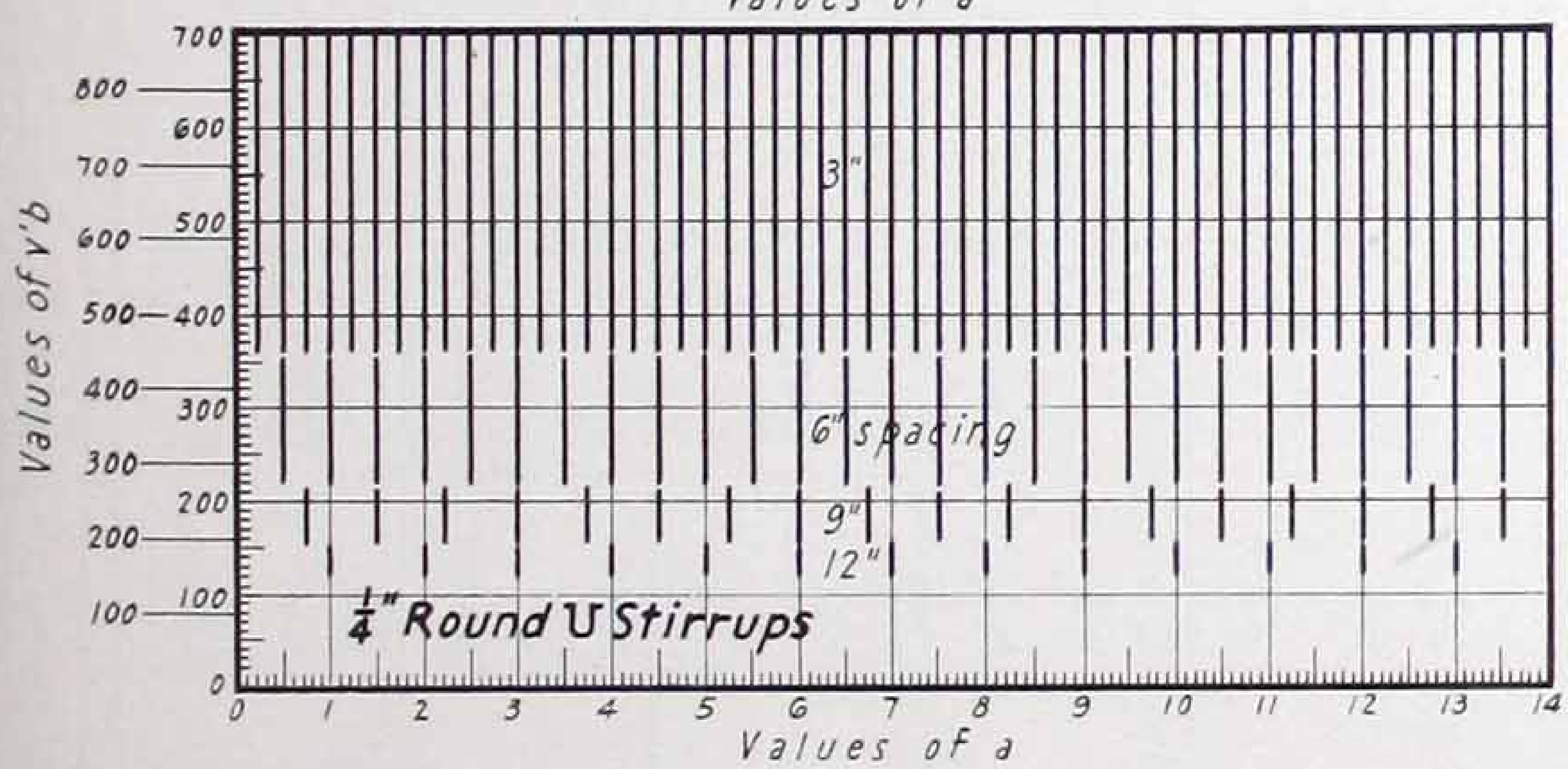
Total Depth of Beam	Effective Depth	Width of Web	Weight per Foot of Beam	Required Area of Steel	Reinforcing Steel			SAFE SUPERIMPOSED LOADS IN LB. PER FT. OF BEAM — SPANS IN FEET (l)																			
					Straight	Bent	c_1 ($A_s = c_1 l$)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
In.	In.	In.	Lb.	Sq. In.	In.	In.																					
12	10	6	75	0.55	1-⅝φ	1-⅝φ	0.072	2010	1710	1400	1090	870	700	580	480	410	340	290	250	220							
		8	100	0.73	1-⅝φ	1-¾φ	0.096	2670	2280	1860	1450	1160	940	770	640	540	460	390	340	290							
		10	125	0.91	1-¾φ	1-¾φ	0.120	3340	2850	2330	1820	1450	1170	970	810	680	570	490	420	360							
14	12	8	117	0.87	1-¾φ	1-¾φ	0.096	3210	2740	2380	2120	1690	1380	1140	950	810	690	590	510	440	380	340	290				
		10	146	1.09	1-¾φ	1-⅞φ	0.120	4010	3410	2970	2640	2110	1720	1420	1190	1010	860	740	640	550	480	420	370				
		12	175	1.31	1-⅞φ	1-1φ	0.144	4820	4100	3570	3170	2540	2070	1710	1430	1210	1030	880	760	660	580	500	440				
16	14	8	133	1.02	1-¾φ	1-⅞φ	0.096	3750	3200	2780	2460	2200	1900	1580	1320	1120	960	830	720	630	550	480	420				
		10	167	1.27	1-⅞φ	1-1φ	0.120	4680	3990	3470	3070	2740	2380	1970	1660	1400	1200	1040	900	780	690	600	530				
		12	200	1.53	1-1φ	1-1φ	0.144	5620	4790	4170	3680	3300	2850	2360	1980	1680	1440	1240	1080	940	820	720	640				
18	16	8	150	1.16	1-⅞φ	1-⅞φ	0.096	4280	3650	3170	2810	2510	2270	2070	1760	1490	1280	1110	960	850	740	660	580				
		10	188	1.46	1-1φ	1-1φ	0.120	5360	4560	3970	3510	3140	2840	2590	2190	1860	1600	1380	1200	1050	930	820	720				
		12	225	1.75	2-¾φ	2-¾φ	0.144	6430	5480	4770	4210	3770	3410	3110	2630	2240	1920	1660	1440	1260	1110	980	870				
		14	262	2.04	2-¾φ	2-⅞φ	0.168	7510	6390	5560	4920	4400	3980	3620	3060	2610	2240	1940	1680	1480	1300	1140	1010				
20	18	8	167	1.31	1-⅞φ	1-1φ	0.096	4820	4100	3570	3160	2830	2550	2330	2140	1910	1640	1420	1240	1090	960	850	760				
		10	208	1.64	2-¾φ	2-¾φ	0.120	6020	5130	4460	3950	3530	3190	2910	2670	2380	2050	1770	1550	1360	1200	1060	940				
		12	250	1.97	2-¾φ	2-⅞φ	0.144	7230	6150	5350	4740	4240	3840	3490	3200	2860	2460	2130	1860	1630	1440	1270	1130				
		14	292	2.29	2-⅞φ	2-⅞φ	0.168	8440	7180	6260	5530	4950	4470	4070	3740	3340	2870	2490	2170	1910	1680	1490	1320				
22	20	10	229	1.82	1-1□	1-1□	0.120					3930	3560	3240	2970	2740	2550	2220	1940	1710	1510	1340	1190	1070	960	860	780
		12	275	2.18	2-⅞φ	2-⅞φ	0.144					4720	4270	3890	3570	3290	3050	2670	2340	2050	1810	1610	1430	1280	1150	1030	930
		14	321	2.55	2-⅞φ	2-1φ	0.168					5500	4980	4540	4160	3840	3560	3110	2720	2390	2120	1880	1670	1500	1340	1210	1090
		16	367	2.91	2-1φ	2-1φ	0.192					6290	5680	5180	4750	4390	4070	3560	3110	2730	2410	2140	1910	1720	1530	1380	1240
24	22	10	250	2.00	1-1□	1-1□	0.120					4330	3910	3570	3270	3020	2800	2610	2380	2090	1850	1650	1470	1320	1190	1070	970
		12	300	2.40	2-⅞φ	2-⅞φ	0.144					5190	4690	4280	3920	3620	3360	3130	2850	2510	2220	1980	1760	1580	1420	1280	1160
		14	350	2.80	2-⅞φ	2-1φ	0.168					6050	5480	4990	4570	4220	3920	3650	3330	2930	2590	2310	2060	1850	1660	1490	1350
		16	400	3.20	2-1φ	2-1φ	0.192					6920	6260	5700	5240	4830	4480	4180	3810	3360	2970	2640	2360	2120	1900	1710	1550
26	24	10	271	2.18	1-1φ	2-1φ	0.120					4720	4270	3880	3570	3290	3050	2850	2660	2500	2230	1990	1780	1600	1440	1300	1180
		12	325	2.62	2-⅞φ	2-1φ	0.144					5670	5130	4670	4290	3960	3670	3420	3200	3010	2680	2390	2140	1920	1730	1560	1410
		14	379	3.06	2-1φ	2-1φ	0.168					6610	5970	5440	5000	4610	4280	3990	3730	3500	3130	2780	2490	2240	2010	1820	1650
		16	433	3.49	2-1φ	2-1□	0.192					7560	6830	6220	5720	5270	4890	4560	4270	4010	3580	3190	2850	2560	2310	2080	1890
28	26	12	350	2.84	2-1φ	2-1φ	0.144					6140	5550	5050	4640	4290	3980	3710	3470	3260	3070	2840	2540	2290	2060	1870	1690
		14	408	3.31	2-1φ	2-1□	0.168					7160	6480	5900	5410	5000	4640	4320	4040	3800	3580	3300	2960	2660	2400	2170	1970
		16	467	3.78	2-1□	2-1□	0.192					8180	7390	6730	6180	5710	5290	4940	4620	4340	4080	3780	3380	3050	2750	2480	2250
		18	525	4.26	3-⅞φ	4-⅞φ	0.216					9210	8330	7590	6960	6430	5960	5550	5200	4880	4600	4250	3800	3420	3090	2790	2530
30	28	12	375	3.06	2-1φ	2-1φ	0.144							5450	5000	4630	4290	4000	3740	3510	3310	3120	2960	2680	2420	2190	1990
		14	437	3.57	2-1φ	2-1□	0.168							6350	5820	5380	5000	4650	4360	4090	3850	3640	3440	3120	2820	2550	2320
		16	500	4.08	3-⅞φ	3-1φ	0.192							7270	6670	6150	5710	5330	4990	4680	4410	4160	3940	3570	3230	2920	2650
		18	563	4.59	3-1φ	3-1φ	0.216							8170	7500	6930	6420	5990	5600	5260	4950	4680	4430	4010	3620	3280	2980
		20	625	5.10	3-1φ	4-1φ	0.240							9080	8330	7700	7130	6650	6220	5840	5500	5190	4920	4470	4030	3650	3320

*For all loadings to the right of the heavy zig-zag line, use the area of steel shown in the table. Loads to the left of the heavy line are governed by shear (v=120) and the areas of steel must be computed by means of the coefficient c_1 as indicated.

DIAGRAM FOR STIRRUP SPACING







TO USE THIS CHART

Find the unit shear, $v = \frac{V}{bjd}$ Then $v' = v - v_c$ and distance a, over which stirrups are required = $\frac{l}{2}\left(\frac{v'}{v}\right)$ Compute v'b Place a straight-edge on the diagram connecting the calculated values of a and v'b, and read off the spacing of stirrups where their respective heavy lines cross the straight-edge In case the spacing is greater than the maximum allowable spacing of $\frac{1}{2}$ d, use the last spacing permitted, until distance a is reached. For example: l = 28', b = 14," d = 30" V = 40,500#, the beam having a uniformly distributed load. Required the number and spacing of $\frac{1}{2}$"ϕ U stirrups in each end of the beam, $f_s = 16,000$.

$v = \frac{40,500}{14 \times .875 \times 30} = 110$ p.s.i.

$v' = 110 - 40 = 70$ p.s.i.

$v'b = 14 \times 70 = 980$

$a = \frac{28}{2}\left(\frac{70}{110}\right) = 8.9'$

Max. allowable spacing = .50 x 30 = 15"

From the chart

s = 6", 6", 3 @ 9", 12", 4 @ 15"

No. of stirrups in each end of beam = 10

Fig. 17

f_s = 20,000 p.s.i.
f_c = 800 p.s.i.
n = 15
¾" clear fireproofing

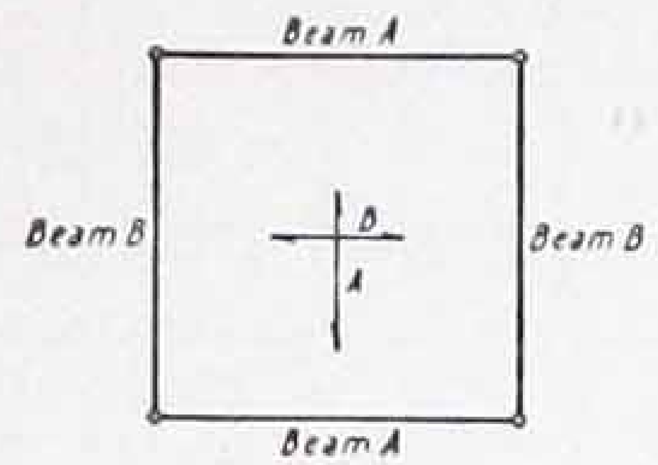
TABLE No. 17 — TWO-WAY SOLID CONCRETE SLABS

SQUARE PANELS

SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET

Total Thickness of Slab In.	Weight per Sq. Ft. Slab Lb.	Volume of Concrete per Sq. Ft. Cu. Ft.	Condition of Continuity: Either Direction	Condition of Continuity: Other Direction	Reinforcing Steel Size and Spacing in Inches: Bottom Layer	Reinforcing Steel Size and Spacing in Inches: Top Layer	10 x 10	11 x 11	12 x 12	13 x 13	14 x 14	15 x 15	16 x 16	17 x 17	18 x 18	19 x 19	20 x 20	21 x 21	22 x 22	23 x 23	24 x 24	25 x 25	26 x 26	27 x 27	28 x 28	29 x 29	30 x 30
4	50	0.333	Simple	Simple	⅜φ-6	⅜φ-5½	178	138	108																		
			End	Simple	⅜φ-5½	⅜φ-5½	163	126	98																		
				End	⅜φ-5½	⅜φ-5½	222	175	139	111																	
			Interior	Simple	⅜φ-6	⅜φ-5½	171	133	103	81																	
				End	⅜φ-6	⅜φ-5½	221	174	138	110	88																
				Interior	⅜φ-6	⅜φ-5½	291	232	187	152	124	102															
4½	56	0.375	Simple	Simple	½φ-10	½φ-8½	227	178	141	112																	
			End	Simple	½φ-8½	½φ-8½	210	164	129	101	80																
				End	½φ-8½	½φ-8½	283	224	180	144	117	95															
			Interior	Simple	½φ-10	½φ-8½	219	172	135	107	84	66															
				End	½φ-10	½φ-8½	281	223	178	143	116	94															
				Interior	½φ-10	½φ-8½		295	239	196	161	133	110														
5	63	0.417	Simple	Simple	½φ-8½	½φ-7½		256	205	165	134	108															
			End	Simple	½φ-7½	½φ-7½		236	188	151	122	98															
				End	½φ-7½	½φ-7½			257	210	172	142	117														
			Interior	Simple	½φ-8½	½φ-7½		247	197	159	128	103	83														
				End	½φ-8½	½φ-7½			257	209	172	141	117	96													
				Interior	½φ-8½	½φ-7½				279	232	194	163	137	115												
5½	69	0.458	Simple	Simple	½φ-7½	½φ-6½			281	229	188	155	128														
			End	Simple	½φ-6½	½φ-6½			259	211	172	141	115	94													
				End	½φ-6½	½φ-6½				287	238	199	166	139	117												
			Interior	Simple	½φ-7½	½φ-6½			271	221	181	149	122	100	82												
				End	½φ-7½	½φ-6½				286	237	198	165	139	116	97											
				Interior	½φ-7½	½φ-6½						267	226	193	164	140	120										
6	75	0.500	Simple	Simple	½φ-6½	½φ-5½					251	208	174	146	122												
			End	Simple	½φ-5½	½φ-5½				289	230	191	159	132	109	91											
				End	½φ-5½	½φ-5½						264	223	189	160	136	116										
			Interior	Simple	½φ-6½	½φ-5½				292	241	201	167	139	116	97	80										
				End	½φ-6½	½φ-5½						263	220	188	159	135	115	97									
				Interior	½φ-6½	½φ-5½								256	221	190	164	142	123								
6½	81	0.542	Simple	Simple	½φ-5½	½φ-5						269	227	191	162	137											
			End	Simple	½φ-5	½φ-5						247	208	175	147	123	104										
				End	½φ-5	½φ-5							287	245	210	180	154	122									
				Simple	½φ-5½	½φ-5						259	218	184	155	131	110	92									

7	88	0.583	Simple	Simple								[illegible]	285	243	208	179	153	131	113	96							
			End	Simple	5/8φ-7	5/8φ-7½						282	237	200	169	142	120	100	84								
				End	5/8φ-7	5/8φ-7½								278	239	205	177	152	131	112							
			Interior	Simple	5/8φ-8½	5/8φ-7½						293	249	210	178	151	127	107	90	75							
				End	5/8φ-8½	5/8φ-7½								277	238	204	176	151	130	112	95						
				Interior	5/8φ-8½	5/8φ-7½										281	244	214	187	164	143	125	109				
7½	94	0.625	Simple	Simple	5/8φ-7½	5/8φ-7								274	234	200	172	147	126								
			End	Simple	5/8φ-6½	5/8φ-7								251	214	183	150	132	112	95							
				End	5/8φ-6½	5/8φ-7										258	223	194	168	146	126	109					
			Interior	Simple	5/8φ-7½	5/8φ-7								264	225	192	164	140	120	101	85	71					
				End	5/8φ-7½	5/8φ-7										257	223	193	168	145	126	108	93				
				Interior	5/8φ-7½	5/8φ-7												267	236	208	183	161	142	125	109		
8	100	0.667	Simple	Simple	5/8φ-7	5/8φ-6½									287	247	213	184	159	137	117						
			End	Simple	5/8φ-6	5/8φ-6½									263	225	194	166	143	122	104	88					
				End	5/8φ-6	5/8φ-6½											275	240	210	184	160	140	122				
			Interior	Simple	5/8φ-7	5/8φ-6½									276	237	204	176	151	130	111	95	80				
				End	5/8φ-7	5/8φ-6½											273	238	208	182	159	138	120	104	90		
				Interior	5/8φ-7	5/8φ-6½														255	226	200	178	158	140	123	109
8½	106	0.708	Simple	Simple	3/4φ-10	3/4φ-8½										277	239	207	179	155	134	115					
			End	Simple	3/4φ-8	3/4φ-8½										253	218	188	162	139	119	101	86				
				End	3/4φ-8	3/4φ-8½												268	236	206	181	158	138	121	104		
			Interior	Simple	3/4φ-10	3/4φ-8½										266	230	198	172	148	127	109	92	78	65		
				End	3/4φ-10	3/4φ-8½												267	234	205	180	157	137	120	104	90	77
				Interior	3/4φ-10	3/4φ-8½															255	277	202	179	159	141	125
9	113	0.750	Simple	Simple	3/4φ-9	3/4φ-8											287	249	217	189	165	143	123	107			
			End	Simple	3/4φ-7½	3/4φ-8											262	227	197	171	147	127	109	93			
				End	3/4φ-7½	3/4φ-8													281	248	218	192	169	149	130	114	99
			Interior	Simple	3/4φ-9	3/4φ-8											275	238	208	180	156	135	116	100	85	71	59
				End	3/4φ-9	3/4φ-8													280	246	217	191	168	148	129	113	98
				Interior	3/4φ-9	3/4φ-8																271	242	216	193	172	153



Condition of Continuity of Slab Direction A	Condition of Continuity of Slab Direction B	Values of 1—er for Bending A	Values of 1—er for Bending B	Values of 1—r for Shear A	Values of 1—r for Shear B
Simple	Simple	0.667	0.667	0.500	0.500
	End	0.575	0.745	0.398	0.602
	Interior	0.485	0.810	0.305	0.695
End	Simple	0.745	0.575	0.604	0.396
	End	0.667	0.667	0.500	0.500
	Interior	0.575	0.745	0.400	0.600
Interior	Simple	0.810	0.485	0.695	0.305
	End	0.745	0.575	0.600	0.400
	Interior	0.667	0.667	0.500	0.500

f_s = 20,000 p.s.i.
f_c = 800 p.s.i.
n = 15
¾" clear fireproofing

TABLE No. 18 — TWO-WAY SOLID CONCRETE SLABS

RATIO OF SPANS 1.2 to 1.0

Total Thickness of Slab	Weight per Sq. Ft. Slab	Volume of Concrete per Sq. Ft.	Condition of Continuity		Reinforcing Steel Size and Spacing in Inches		SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET															
			Short Way of Slab	Long Way of Slab	Short Way (Bottom Layer)	Long Way (Top Layer)	12 x 10	13.2 x 11	14.4 x 12	15.6 x 13	16.8 x 14	18 x 15	19.2 x 16	20.4 x 17	21.6 x 18	22.8 x 19	24 x 20	25.2 x 21	26.4 x 22	27.6 x 23	28.8 x 24	30 x 25
In.	Lb.	Cu. Ft.																				
4	50	0.333	Simple	Simple	⅜φ-4½	⅜φ-5½	169															
				End	⅜φ-4½	⅜φ-5	161	124														
				Interior	⅜φ-8	⅜φ-5½	153	118	91													
			End	Simple	⅜φ-4	⅜φ-7½	164	127														
				End	⅜φ-4	⅜φ-5	212	166	132													
				Interior	⅜φ-4	⅜φ-5½	208	163	129													
			Interior	Simple	⅜φ-4½	⅜φ-10	174	135	106													
				End	⅜φ-4½	⅜φ-10	219	172	137													
				Interior	⅜φ-4½	⅜φ-5½	278	221	178	144												
4½	56	0.375	Simple	Simple	½φ-7½	½φ-8½	230	180	143													
				End	½φ-7½	½φ-8	208	163	128	100												
				Interior	⅜φ-7½	½φ-8½	197	153	120	94												
			End	Simple	½φ-6	⅜φ-6½	223	174	138													
				End	½φ-6	½φ-8	286	226	181	146												
				Interior	½φ-6	½φ-8½	267	211	168	135	109											
			Interior	Simple	½φ-7½	⅜φ-9	237	186	147	117												
				End	½φ-7½	⅜φ-9½	295	234	188	152	123											
				Interior	½φ-7½	½φ-8½			242	198	163	135										
5	63	0.417	Simple	Simple	½φ-6½	½φ-7½	310	245	196	158												
				End	½φ-6½	½φ-6½	297	235	187	150	121											
				Interior	⅜φ-6½	½φ-7½	281	221	176	141	112	90										
			End	Simple	½φ-5½	⅜φ-6	302	239	190	153	123											
				End	½φ-5½	½φ-7		306	247	201	165	135										
				Interior	½φ-5½	½φ-7½		301	243	197	161	132	109									
			Interior	Simple	½φ-6½	⅜φ-8	319	243	202	163	132	107										
				End	½φ-6½	⅜φ-8			256	208	171	141	116									
				Interior	½φ-6½	½φ-7½				268	223	186	156	131								
5½	69	0.458	Simple	Simple	½φ-5½	½φ-7			259	211	172	141										
				End	½φ-5½	½φ-5½			258	209	171	140										
				Interior	½φ-9½	½φ-6½			243	197	161	131	107									
			End	Simple	½φ-4½	½φ-9½			251	204	166	136										
				End	½φ-4½	½φ-6½					220	182	152									
				Interior	½φ-4½	½φ-6½				271	224	186	155	130								
			Interior	Simple	½φ-5½	⅜φ-7			267	217	178	146	120									
				End	½φ-5½	⅜φ-7				274	227	189	157	131								
				Interior	½φ-5½	½φ-7					293	246	208	176	149							
6	75	0.500	Simple	Simple	½φ-5	½φ-6				270	223	184	153									
				End	½φ-5	½φ-5				277	229	189	157	131								
				Interior	½φ-8½	½φ-5½				262	215	178	147	122	101							
			End	Simple	½φ-4	½φ-8½				262	216	178	147	122								
				End	½φ-4	½φ-5½					281	235	197	166	140							
				Interior	½φ-4	½φ-5½					296	248	209	177	149	126						
				Simple	[illegible]	[illegible]				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							

				Simple	½φ-5	5/8φ-6½				278	230	190	158	131	109							
6½	81	0.542	Simple	Simple	5/8φ-7½	5/8φ-9					271	220	188	156								
				End	5/8φ-7½	5/8φ-7½					266	221	185	155	129							
				Interior	½φ-8	5/8φ-8½					251	208	173	144	119	99						
			End	Simple	5/8φ-6	½φ-8					261	218	182	152	127							
				End	5/8φ-6	5/8φ-8						285	241	204	173	148						
				Interior	5/8φ-6	5/8φ-8½						288	244	207	175	149	127	107				
			Interior	Simple	5/8φ-7½	5/8φ-6					279	233	195	163	137	114						
				End	5/8φ-7½	5/8φ-6								212	180	153	130					
				Interior	5/8φ-7½	5/8φ-9								276	238	205	177	153	132			
7	88	0.583	Simple	Simple	5/8φ-6½	5/8φ-8						278	233	196	166	140						
				End	5/8φ-6½	5/8φ-6½						280	236	199	168	142	119					
				Interior	½φ-7½	5/8φ-7½						264	222	186	156	131	110	92				
			End	Simple	5/8φ-5½	½φ-7						270	226	190	160	135	113					
				End	5/8φ-5½	5/8φ-7½								252	216	184	158	135				
				Interior	5/8φ-5½	5/8φ-7½								262	225	193	165	141	121			
			Interior	Simple	5/8φ-6½	½φ-10						286	241	203	172	145	122	103				
				End	5/8φ-6½	½φ-10								261	223	192	164	141	120			
				Interior	5/8φ-6½	5/8φ-8										254	220	191	167	145		
7½	94	0.625	Simple	Simple	5/8φ-6	5/8φ-7½							283	240	204	174	147					
				End	5/8φ-6	5/8φ-6							294	250	213	181	154	131				
				Interior	½φ-6½	5/8φ-7							277	234	199	169	144	121	102	86		
			End	Simple	5/8φ-5	½φ-6½							275	233	197	168	142	120				
				End	5/8φ-5	5/8φ-7									262	226	194	167	144			
				Interior	5/8φ-5	5/8φ-7									280	242	209	181	157	136	117	
			Interior	Simple	5/8φ-6	½φ-9							292	248	211	180	153	130	110			
				End	5/8φ-6	½φ-9									271	234	202	174	151	130		
				Interior	5/8φ-6	5/8φ-7½											268	234	206	180	158	138
8	100	0.667	Simple	Simple	5/8φ-5½	5/8φ-7								288	246	211	181	154				
				End	5/8φ-5½	5/8φ-5½								305	261	224	192	165	142	121		
				Interior	5/8φ-9	5/8φ-6½								287	245	209	179	153	130	111	94	
			End	Simple	5/8φ-4½	5/8φ-10								280	239	204	174	149	127			
				End	5/8φ-4½	5/8φ-6½										271	235	204	177	153	133	
				Interior	5/8φ-4½	5/8φ-6½											257	224	196	170	148	
			Interior	Simple	5/8φ-5½	½φ-8½									255	218	187	160	137	117	99	84
				End	5/8φ-5½	½φ-8½										282	245	212	185	161	139	120
				Interior	5/8φ-5½	5/8φ-7												281	248	218	192	169
8½	105	0.708	Simple	Simple	¾φ-8	¾φ-9½									286	246	211	181	156	134		
				End	¾φ-8	¾φ-7½									292	251	216	186	160	138	118	
				Interior	5/8φ-8½	¾φ-8½									275	236	202	174	149	127	108	91
			End	Simple	¾φ-6½	5/8φ-9									276	239	204	175	150	128	109	
				End	¾φ-6½	¾φ-8½											273	238	207	181	157	137
				Interior	¾φ-6½	¾φ-8½												251	220	192	168	146
			Interior	Simple	¾φ-8	½φ-8										254	219	188	162	139	120	102
				End	¾φ-8	½φ-8											284	247	216	189	164	143
				Interior	¾φ-8	¾φ-9½														254	224	198
9	113	0.750	Simple	Simple	¾φ-7½	¾φ-9										287	249	215	186	160	138	
				End	¾φ-7½	¾φ-7										300	259	225	195	169	146	125
				Interior	5/8φ-8	¾φ-8										282	243	210	181	157	134	115
			End	Simple	¾φ-6	5/8φ-8½										279	240	207	179	154	132	113
				End	¾φ-6	¾φ-8												279	244	214	187	164
				Interior	¾φ-6	¾φ-8													263	231	203	178
			Interior	Simple	¾φ-7½	½φ-7½											257	222	193	167	144	123
				End	¾φ-7½	½φ-7½													254	222	195	171
				Interior	¾φ-7½	¾φ-9															263	234

1—r For Shear	
For Long Beam	For Short Beam
0.633	0.367
0.532	0.468
0.432	0.568
0.725	0.275
0.633	0.367
0.535	0.465
0.796	0.204
0.722	0.278
0.633	0.367

1—er For Bending	
For Long Beam	For Short Beam
0.768	0.550
0.690	0.640
0.610	0.720
0.830	0.450
0.768	0.550
0.695	0.637
0.877	0.340
0.830	0.450
0.768	0.550

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
¾" clear fireproofing

TABLE No. 19
TWO-WAY SOLID CONCRETE SLABS

RATIO OF SPANS 1.4 to 1.0

Total Thickness of Slab In.	Weight per Sq. Ft. Slab Lb.	Volume of Concrete per Sq. Ft. Cu. Ft.	Condition of Continuity: Short Way of Slab	Condition of Continuity: Long Way of Slab	Reinforcing Steel Size and Spacing in Inches: Short Way (Bottom Layer)	Reinforcing Steel Size and Spacing in Inches: Long Way (Top Layer)	14 x 10	15.4 x 11	16.8 x 12	18.2 x 13	19.6 x 14	21 x 15	22.4 x 16	23.8 x 17	25.2 x 18	26.6 x 19	28 x 20	29.4 x 21	30 x 21.4
							SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET												
4	50	0.333	Simple	Simple	⅜φ-4½	⅜φ-7	126												
				End	⅜φ-4½	⅜φ-5	164												
				Interior	⅜φ-4½	⅜φ-5½	147	113											
			End	Simple	⅜φ-4	⅜φ-10	124												
				End	⅜φ-4	⅜φ-6½	160	123											
				Interior	⅜φ-4	⅜φ-5½	206	161											
			Interior	Simple	⅜φ-4½	⅜φ-10	136												
				End	⅜φ-4½	⅜φ-10	169	131											
				Interior	⅜φ-4½	⅜φ-7	214	168	133										
4½	56	0.375	Simple	Simple	½φ-7½	⅜φ-6	173	133											
				End	½φ-7½	½φ-7½	223	175											
				Interior	½φ-7½	½φ-8½	189	146	114										
			End	Simple	½φ-6	⅜φ-8½	172	132											
				End	½φ-6	⅜φ-6	218	171	134										
				Interior	½φ-6	½φ-8½	278	220	176	142									
			Interior	Simple	½φ-7½	⅜φ-10	187	144	112										
				End	½φ-7½	⅜φ-10	230	181	143	113									
				Interior	½φ-7½	⅜φ-6	289	229	183	148	120								
5	63	0.417	Simple	Simple	½φ-6½	½φ-10	237	185	145										
				End	½φ-6½	½φ-6½	302	238	190	153									
				Interior	½φ-6½	½φ-7½	271	213	169	135	107								
			End	Simple	½φ-5½	⅜φ-7½	234	183	143	113									
				End	½φ-5½	⅜φ-5	295	233	186	149									
				Interior	½φ-5½	½φ-7½		298	240	195	160								
			Interior	Simple	½φ-6½	⅜φ-9½	254	199	157	124									
				End	½φ-6½	⅜φ-9½	311	246	197	158	128								
				Interior	½φ-6½	½φ-10		309	249	203	167	137							
5½	69	0.458	Simple	Simple	½φ-5½	½φ-9		245	195	156									
				End	½φ-5½	½φ-6		313	252	204	167								
				Interior	½φ-5½	½φ-6½		291	234	189	153	125							
			End	Simple	½φ-4½	⅜φ-7		242	193	154	123								
				End	½φ-4½	½φ-8		306	246	199	162	132							
				Interior	½φ-4½	½φ-6½				258	213	177	147						
			Interior	Simple	½φ-5½	⅜φ-8½		263	210	168	135	109							
				End	½φ-5½	⅜φ-8½			260	211	173	141	116						
				Interior	½φ-5½	½φ-9				268	222	184	154	128					
6	75	0.500	Simple	Simple	½φ-5	½φ-8			250	202	164	133							
				End	½φ-5	½φ-5				262	216	178							
				Interior	½φ-5	½φ-5½				252	207	171	141	116					
			End	Simple	½φ-4	⅜φ-6			248	200	162	131							
				End	½φ-4	½φ-7½				256	211	174	144						
				Interior	½φ-4	½φ-6					273	228	191	161					
				Simple	½φ-5	⅜φ-7½			270	219	178	145	119						

6½	81	0.542	Simple	Simple	5/8φ-7½	1/2φ-7				246	201	165	135						
				End	5/8φ-7½	5/8φ-7½					263	218	182	152					
				Interior	5/8φ-7½	5/8φ-8½					241	199	165	137	114				
			End	Simple	5/8φ-6	3/8φ-5½				245	199	163	134						
				End	5/8φ-6	1/2φ-6½					257	213	177	148	123				
				Interior	5/8φ-6	5/8φ-8½						277	234	198	167	142			
			Interior	Simple	5/8φ-7½	3/8φ-7				265	217	179	147	121					
				End	5/8φ-7½	3/8φ-7					271	226	189	158	132				
				Interior	5/8φ-7½	1/2φ-7						289	244	207	176	149	127		
7	88	0.583	Simple	Simple	5/8φ-6½	1/2φ-6½					250	206	170	141	116				
				End	5/8φ-6½	5/8φ-7						270	226	190	160				
				Interior	5/8φ-6½	5/8φ-7½						254	212	178	149	125			
			End	Simple	5/8φ-5½	1/2φ-9					246	203	168	138	114				
				End	5/8φ-5½	1/2φ-6						263	220	185	150	131			
				Interior	5/8φ-5½	5/8φ-8							288	245	209	178	152		
			Interior	Simple	5/8φ-6½	3/8φ-6½					269	222	185	154	128	105			
				End	5/8φ-6½	3/8φ-6½						278	234	197	166	140	118		
				Interior	5/8φ-6½	1/2φ-6½								255	218	187	160	137	128
7½	94	0.625	Simple	Simple	5/8φ-6	1/2φ-6½						250	209	174	145				
				End	5/8φ-6	5/8φ-6½							274	232	197	167			
				Interior	5/8φ-6	5/8φ-7							266	224	190	161	136	114	
			End	Simple	5/8φ-5	1/2φ-8½						248	206	172	143	119			
				End	5/8φ-5	5/8φ-9							268	226	192	163	138		
				Interior	5/8φ-5	5/8φ-7									255	219	188	162	153
			Interior	Simple	5/8φ-6	3/8φ-6						270	226	190	159	133	111		
				End	5/8φ-6	3/8φ-6							284	241	205	174	148	125	117
				Interior	5/8φ-6	1/2φ-6½									265	228	196	170	160
8	100	0.667	Simple	Simple	5/8φ-5½	5/8φ-9							252	212	178	150	125		
				End	5/8φ-5½	5/8φ-6								280	239	204	174	149	
				Interior	5/8φ-5½	5/8φ-6½								275	235	200	171	146	136
			End	Simple	5/8φ-4½	1/2φ-8							250	210	176	148	124		
				End	5/8φ-4½	5/8φ-8½								272	232	198	169	144	135
				Interior	5/8φ-4½	5/8φ-6½										264	228	197	186
			Interior	Simple	5/8φ-5½	1/2φ-10							273	230	195	164	139	116	108
				End	5/8φ-5½	1/2φ-10								289	247	211	181	155	145
				Interior	5/8φ-5½	5/8φ-9										275	238	207	195
8½	106	0.708	Simple	Simple	3/4φ-8	5/8φ-8½								246	209	176	149	125	
				End	3/4φ-8	3/4φ-8									276	237	204	175	164
				Interior	3/4φ-8	3/4φ-8½									263	225	193	165	154
			End	Simple	3/4φ-6½	1/2φ-7½								244	205	174	146	123	114
				End	3/4φ-6½	5/8φ-8									270	231	198	170	160
				Interior	3/4φ-6½	3/4φ-9											264	230	217
			Interior	Simple	3/4φ-8	1/2φ-9								266	226	192	162	137	129
				End	3/4φ-8	1/2φ-9									286	245	211	182	171
				Interior	3/4φ-8	5/8φ-8½											276	240	228
9	113	0.750	Simple	Simple	3/4φ-7½	5/8φ-8									245	208	177	150	140
				End	3/4φ-7½	3/4φ-7½										278	240	207	195
				Interior	3/4φ-7½	3/4φ-8										270	233	200	188
			End	Simple	3/4φ-6	1/2φ-7									243	206	175	148	139
				End	3/4φ-6	5/8φ-7½										272	234	202	190
				Interior	3/4φ-6	3/4φ-8½													256
			Interior	Simple	3/4φ-7½	1/2φ-8½									267	227	194	165	155
				End	3/4φ-7½	1/2φ-8½										288	249	215	203
				Interior	3/4φ-7½	5/8φ-8													

1—r For Shear	
For Long Beam	For Short Beam
0.733	0.267
0.644	0.356
0.546	0.454
0.807	0.193
0.733	0.267
0.647	0.353
0.863	0.137
0.805	0.195
0.733	0.267

1—er For Bending	
For Long Beam	For Short Beam
0.835	0.440
0.775	0.540
0.705	0.625
0.882	0.325
0.835	0.440
0.775	0.540
0.920	0.205
0.880	0.327
0.835	0.440

f_s = 20,000 p.s.i.
f_c = 800 p.s.i.
n = 15
¾" clear fireproofing

TABLE No. 20
TWO-WAY SOLID CONCRETE SLABS

RATIO OF SPANS 1.6 to 1.0

Total Thickness of Slab	Weight per Sq. Ft. Slab	Volume of Concrete per Sq. Ft.	Condition of Continuity		Reinforcing Steel Size and Spacing in Inches		SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET									
			Short Way of Slab	Long Way of Slab	Short Way (Bottom Layer)	Long Way (Top Layer)	16 x 10	17.6 x 11	19.2 x 12	20.8 x 13	22.4 x 14	24 x 15	25.6 x 16	27.2 x 17	28.8 x 18	30 x 18.75
In.	Lb.	Cu. Ft.														
4	50	0.333	Simple	Interior	3/8φ-4½	3/8φ-5½	146									
			End	End	3/8φ-4	3/8φ-8½	126									
				Interior	3/8φ-4	3/8φ-6½	160	124								
			Interior	Simple	3/8φ-4½	3/8φ-10	114									
				End	3/8φ-4½	3/8φ-10	137									
				Interior	3/8φ-4½	3/8φ-9	170	132								
4½	56	0.375	Simple	Simple	½φ-7½	3/8φ-8	136									
				End	½φ-7½	½φ-10	175	135								
				Interior	½φ-7½	½φ-8½	190	147								
			End	Simple	½φ-6	3/8φ-10	137									
				End	½φ-6	3/8φ-7½	173	133								
				Interior	½φ-6	3/8φ-6	218	170	134							
			Interior	Simple	½φ-7½	3/8φ-10	158	121								
				End	½φ-7½	3/8φ-10	188	146	113							
				Interior	½φ-7½	3/8φ-8	232	182	144	114						
5	63	0.417	Simple	Simple	½φ-6½	3/8φ-7	188	144								
				End	½φ-6½	½φ-8½	239	186	147							
				Interior	½φ-6½	½φ-7½	272	234	170	135						
			End	Simple	½φ-5½	3/8φ-9½	190	146	102							
				End	½φ-5½	3/8φ-6½	237	185	145							
				Interior	½φ-5½	3/8φ-5	295	233	185	149						
			Interior	Simple	½φ-6½	3/8φ-9½	217	168	131							
				End	½φ-6½	3/8φ-9½	256	200	158	126						
				Interior	½φ-6½	3/8φ-7	313	247	198	159	129					
5½	69	0.458	Simple	Simple	½φ-5½	3/8φ-6	248	193	151							
				End	½φ-5½	½φ-7½	313	247	197	157						
				Interior	½φ-5½	½φ-6½			235	190	154					
			End	Simple	½φ-4½	3/8φ-8½	251	195	153	120						
				End	½φ-4½	3/8φ-6	310	244	194	155	124					
				Interior	½φ-4½	3/8φ-4½		306	246	199	162	133				
			Interior	Simple	½φ-5½	3/8φ-8½	285	223	177	140						
				End	½φ-5½	3/8φ-8½		265	211	170	137					
				Interior	½φ-5½	3/8φ-6			261	212	173	142				
6	75	0.500	Simple	Simple	½φ-5	3/8φ-5½		241	190	156						
				End	½φ-5	½φ-6½			253	204	166					
				Interior	½φ-5	½φ-5½				253	207	171				
			End	Simple	½φ-4	3/8φ-7½		251	199	159	126					
				End	½φ-4	3/8φ-5			251	202	154	123				
				Interior	½φ-4	3/8φ-4				256	211	164	144			

6½	81	0.542	Simple	Simple	⅝φ-7½	½φ-9		302	241	193	155	125				
				End	⅝φ-7½	⅝φ-9½				250	204	167	137			
				Interior	⅝φ-7½	⅝φ-8					242	201	166	138		
			End	Simple	⅝φ-6	⅜φ-7		305	243	195	157	127				
				End	⅝φ-6	½φ-8½			304	247	201	155	135			
				Interior	⅝φ-6	½φ-7					257	213	177	148		
			Interior	Simple	⅝φ-7½	⅜φ-7			278	225	183	149	121			
				End	⅝φ-7½	⅜φ-7				268	220	181	159	123		
				Interior	⅝φ-7½	½φ-9					273	228	190	169	133	111
7	88	0.583	Simple	Simple	⅝φ-6½	½φ-8½			296	239	194	158	128			
				End	⅝φ-6½	⅝φ-9					252	208	172	142		
				Interior	⅝φ-6½	⅝φ-7½						255	213	179	150	
			End	Simple	⅝φ-5½	⅜φ-6½			289	241	196	159	130			
				End	⅝φ-5½	½φ-8				302	249	205	170	140		
				Interior	⅝φ-5½	½φ-6½						263	220	185		
			Interior	Simple	⅝φ-6½	⅜φ-6½				276	226	186	162	125	102	87
				End	⅝φ-6½	⅜φ-6½					270	224	186	155	129	112
				Interior	⅝φ-6½	½φ-8½						280	235	198	167	147
7½	94	0.625	Simple	Simple	⅝φ-6	½φ-8				290	237	195	159	130		
				End	⅝φ-6	⅝φ-8						253	211	176	147	
				Interior	⅝φ-6	⅝φ-7							267	226	191	168
			End	Simple	⅝φ-5	⅜φ-6				293	240	196	161	132	107	
				End	⅝φ-5	½φ-7						251	209	174	135	127
				Interior	⅝φ-5	½φ-6							268	227	192	170
			Interior	Simple	⅝φ-6	⅜φ-6					275	227	189	156	129	112
				End	⅝φ-6	⅜φ-6						273	228	192	161	131
				Interior	⅝φ-6	½φ-8							286	242	206	173
8	100	0.667	Simple	Simple	⅝φ-5½	½φ-7½					285	235	195	161	133	
				End	⅝φ-5½	⅝φ-7½							255	215	181	159
				Interior	⅝φ-5½	⅝φ-6								276	236	209
			End	Simple	⅝φ-4½	½φ-10					238	238	197	163	134	116
				End	⅝φ-4½	½φ-6½							252	212	178	156
				Interior	⅝φ-4½	½φ-5½								273	232	207
			Interior	Simple	⅝φ-5½	½φ-10						273	228	191	159	139
				End	⅝φ-5½	½φ-10							275	232	196	173
				Interior	⅝φ-5½	½φ-7½								291	248	221
8½	106	0.708	Simple	Simple	¾φ-8	½φ-7						273	227	189	157	136
				End	¾φ-8	¾φ-10								250	211	186
				Interior	¾φ-8	¾φ-8½									264	235
			End	Simple	¾φ-6½	½φ-9						275	229	191	159	138
				End	¾φ-6½	½φ-6							292	246	208	184
				Interior	¾φ-6½	½φ-5									270	240
			Interior	Simple	¾φ-8	½φ-9							266	223	187	164
				End	¾φ-8	½φ-9								269	228	102
				Interior	¾φ-8	½φ-7										258
9	113	0.750	Simple	Simple	¾φ-7½	½φ-6½							267	223	187	164
				End	¾φ-7½	¾φ-9½								292	248	220
				Interior	¾φ-7½	¾φ-8										281
			End	Simple	¾φ-6	½φ-8½							269	226	189	166
				End	¾φ-6	½φ-6								288	245	217
				Interior	¾φ-6	½φ-5										282
			Interior	Simple	¾φ-7½	½φ-8½								262	221	195
				End	¾φ-7½	½φ-8½									268	239
				Interior	¾φ-7½	½φ-6½										302

1—r For Shear	
For Long Beam	For Short Beam
0.804	0.196
0.730	0.270
0.643	0.357
0.862	0.138
0.804	0.196
0.732	0.268
0.904	0.096
0.860	0.140
0.804	0.196

1—er For Bending	
For Long Beam	For Short Beam
0.880	0.330
0.833	0.445
0.775	0.540
0.920	0.205
0.880	0.330
0.835	0.440
0.944	0.098
0.918	0.210
0.880	0.330

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
¾" clear fireproofing

TABLE No. 21—TWO-WAY SOLID CONCRETE SLABS

RATIO OF SPANS 1.8 to 1.0

Total Thickness of Slab In.	Weight per Sq. Ft. Slab Lb.	Volume of Concrete per Sq. Ft. Cu. Ft.	Condition of Continuity: Short Way of Slab	Condition of Continuity: Long Way of Slab	Reinforcing Steel Size and Spacing in Inches: Short Way (Bottom Layer)	Reinforcing Steel Size and Spacing in Inches: Long Way (Top Layer)	Safe Superimposed Loads in Lb. per Sq. Ft. — Spans in Feet: 18 x 10	19.8 x 11	21.6 x 12	23.4 x 13	25.2 x 14	27 x 15	28.8 x 16	30 x 16.7
4½	56	0.375	Simple	End	½φ-7½	⅜φ-6½	140							
				Interior	½φ-7½	⅜φ-5	180	139						
			End	Simple	½φ-6	⅜φ-10	115							
				End	½φ-6	⅜φ-10	141							
				Interior	½φ-6	⅜φ-7	177	136						
			Interior	Simple	½φ-7½	⅜φ-10	152							
				End	½φ-7½	⅜φ-10	159	122						
				Interior	½φ-7½	⅜φ-10	191	148	116					
5	63	0.417	Simple	Simple	½φ-6½	⅜φ-9	152							
				End	½φ-6½	⅜φ-6	193	149						
				Interior	½φ-6½	⅜φ-4½	245	191	151					
			End	Simple	½φ-5½	⅜φ-9	160	121						
				End	½φ-5½	⅜φ-8½	195	150						
				Interior	½φ-5½	⅜φ-6½	241	189	148					
			Interior	Simple	½φ-6½	⅜φ-9½	208	161						
				End	½φ-6½	⅜φ-9½	218	169	132					
				Interior	½φ-6½	⅜φ-9	260	204	161	128				
5½	69	0.458	Simple	Simple	½φ-5½	⅜φ-8	203							
				End	½φ-5½	⅜φ-5	256	199	157					
				Interior	½φ-5½	⅜φ-4		253	202	161				
			End	Simple	½φ-4½	⅜φ-8	213	164	127					
				End	½φ-4½	⅜φ-7½	257	200	157	124				
				Interior	½φ-4½	⅜φ-6	316	249	199	159	128			
			Interior	Simple	½φ-5½	⅜φ-8½	274	215	169					
				End	½φ-5½	⅜φ-8½	286	224	177	141				
				Interior	½φ-5½	⅜φ-8		269	215	173	139			
6	75	0.500	Simple	Simple	½φ-5	⅜φ-7½	261	203	159					
				End	½φ-5	½φ-8½		257	204	162				
				Interior	½φ-5	½φ-6½			259	209	170			
			End	Simple	½φ-4	⅜φ-7	274	213	167	131				
				End	½φ-4	⅜φ-6½		258	205	163	130			
				Interior	½φ-4	⅜φ-5½			256	207	168	136		
			Interior	Simple	½φ-5	⅜φ-7½		275	219	176				
				End	½φ-5	⅜φ-7½		288	230	184	149			
				Interior	½φ-5	⅜φ-7½			276	224	183	149	122	
6½	81	0.542	Simple	Simple	⅝φ-7½	⅜φ-6½	317	248	195	154				
				End	⅝φ-7½	½φ-7½		311	248	199	161			
				Interior	⅝φ-7½	½φ-6				255	209	172	141	
			End	Simple	⅝φ-6	⅜φ-6½		260	205	163	129			
				End	⅝φ-6	⅜φ-6			250	201	162	130		
				Interior	⅝φ-6	½φ-8½				251	206	169	138	121

7	83	0.583	Simple	Simple	$\frac{5}{8}\phi$–6½	$\frac{3}{8}\phi$–6		305	242	193	154	123		
				End	$\frac{5}{8}\phi$–6½	$\frac{1}{2}\phi$–7			304	256	200	163	133	
				Interior	$\frac{5}{8}\phi$–6½	$\frac{1}{2}\phi$–5½					258	214	177	156
			End	Simple	$\frac{5}{8}\phi$–5½	$\frac{3}{8}\phi$–6			254	203	163	131		
				End	$\frac{5}{8}\phi$–5½	$\frac{3}{8}\phi$–5½			306	248	171	164	133	116
				Interior	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–8					255	210	174	154
			Interior	Simple	$\frac{5}{8}\phi$–6½	$\frac{3}{8}\phi$–6½				266	217	178	145	
				End	$\frac{5}{8}\phi$–6½	$\frac{3}{8}\phi$–6½				278	228	187	154	134
				Interior	$\frac{5}{8}\phi$–6½	$\frac{3}{8}\phi$–6					276	228	190	168
7½	94	0.625	Simple	Simple	$\frac{5}{8}\phi$–6	$\frac{3}{8}\phi$–5½			293	236	190	154	124	
				End	$\frac{5}{8}\phi$–6	$\frac{1}{2}\phi$–6½				299	244	201	165	145
				Interior	$\frac{5}{8}\phi$–6	$\frac{1}{2}\phi$–5						260	217	193
			End	Simple	$\frac{5}{8}\phi$–5	$\frac{3}{8}\phi$–5½			307	247	200	162	131	114
				End	$\frac{5}{8}\phi$–5	$\frac{3}{8}\phi$–5					246	202	166	146
				Interior	$\frac{5}{8}\phi$–5	$\frac{1}{2}\phi$–7						256	213	189
			Interior	Simple	$\frac{5}{8}\phi$–6	$\frac{3}{8}\phi$–6					264	218	180	159
				End	$\frac{5}{8}\phi$–6	$\frac{3}{8}\phi$–6						229	190	169
				Interior	$\frac{5}{8}\phi$–6	$\frac{3}{8}\phi$–5½						278	232	207
8	100	0.667	Simple	Simple	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–10				283	231	188	153	133
				End	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–6					294	243	202	178
				Interior	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–5							262	234
			End	Simple	$\frac{5}{8}\phi$–4½	$\frac{1}{2}\phi$–9				297	242	198	162	142
				End	$\frac{5}{8}\phi$–4½	$\frac{1}{2}\phi$–8½					295	244	202	179
				Interior	$\frac{5}{8}\phi$–4½	$\frac{1}{2}\phi$–6½							258	230
			Interior	Simple	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–10						263	219	194
				End	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–10						276	230	204
				Interior	$\frac{5}{8}\phi$–5½	$\frac{1}{2}\phi$–10								250
8½	106	0.708	Simple	Simple	$\frac{3}{4}\phi$–8	$\frac{1}{2}\phi$–9					268	219	180	157
				End	$\frac{3}{4}\phi$–8	$\frac{1}{2}\phi$–5½						282	234	208
				Interior	$\frac{3}{4}\phi$–8	$\frac{1}{2}\phi$–4½								271
			End	Simple	$\frac{3}{4}\phi$–6½	$\frac{1}{2}\phi$–8½					281	231	190	167
				End	$\frac{3}{4}\phi$–6½	$\frac{1}{2}\phi$–8						283	236	209
				Interior	$\frac{3}{4}\phi$–6½	$\frac{1}{2}\phi$–6½								266
			Interior	Simple	$\frac{3}{4}\phi$–8	$\frac{1}{2}\phi$–9							254	226
				End	$\frac{3}{4}\phi$–8	$\frac{1}{2}\phi$–9							266	237
				Interior	$\frac{3}{4}\phi$–8	$\frac{1}{2}\phi$–9								289
9	113	0.750	Simple	Simple	$\frac{3}{4}\phi$–7½	$\frac{1}{2}\phi$–8½						258	213	187
				End	$\frac{3}{4}\phi$–7½	$\frac{1}{2}\phi$–5							275	245
				Interior	$\frac{3}{4}\phi$–7½	$\frac{1}{2}\phi$–4								316
			End	Simple	$\frac{3}{4}\phi$–6	$\frac{1}{2}\phi$–8						271	225	198
				End	$\frac{3}{4}\phi$–6	$\frac{1}{2}\phi$–7½							277	246
				Interior	$\frac{3}{4}\phi$–6	$\frac{1}{2}\phi$–6								312
			Interior	Simple	$\frac{3}{4}\phi$–7½	$\frac{1}{2}\phi$–8½								265
				End	$\frac{3}{4}\phi$–7½	$\frac{1}{2}\phi$–8½								278
				Interior	$\frac{3}{4}\phi$–7½	$\frac{1}{2}\phi$–8½								338

1—r For Shear	
For Long Beam	For Short Beam
0.854	0.146
0.794	0.206
0.719	0.281
0.899	0.101
0.854	0.146
0.796	0.204
0.930	0.070
0.898	0.102
0.854	0.146

1—er For Bending	
For Long Beam	For Short Beam
0.915	0.220
0.875	0.345
0.825	0.455
0.942	0.100
0.915	0.220
0.875	0.340
0.961	0.070
0.941	0.102
0.915	0.220

$f_s = 20{,}000$ p.s.i.
$f_c = 800$ p.s.i.
$n = 15$
¾" clear fireproofing

TABLE No. 22—TWO-WAY SOLID CONCRETE SLABS

RATIO OF SPANS 2.0 to 1.0

Total Thickness of Slab	Weight per Sq. Ft. Slab	Volume of Concrete per Sq. Ft.	Condition of Continuity		Reinforcing Steel Size and Spacing in Inches		SAFE SUPERIMPOSED LOADS IN LB. PER SQ. FT. — SPANS IN FEET					
			Short Way of Slab	Long Way of Slab	Short Way (Bottom Layer)	Long Way (Top Layer)	20 x 10	22 x 11	24 x 12	26 x 13	28 x 14	30 x 15
In.	Lb.	Cu. Ft.										
4½	56	0.375	Simple	Interior	½φ-7½	⅜φ-6	148					
			End	End	½φ-6	⅜φ-10	117					
				Interior	½φ-6	⅜φ-9	149					
			Interior	End	½φ-7½	⅜φ-10	153					
				Interior	½φ-7½	⅜φ-10	161	123				
5	63	0.417	Simple	Simple	½φ-6½	⅜φ-9½	126					
				End	½φ-6½	⅜φ-7	162					
				Interior	½φ-6½	⅜φ-5½	204	158				
			End	Simple	½φ-5½	⅜φ-9	154					
				End	½φ-5½	⅜φ-9	163	124				
				Interior	½φ-5½	⅜φ-8	205	158	123			
			Interior	Simple	½φ-6½	⅜φ-9½	201					
				End	½φ-6½	⅜φ-9½	210	163				
				Interior	½φ-6½	⅜φ-9½	220	171	134			
5½	69	0.458	Simple	Simple	½φ-5½	⅜φ-8½	170	129				
				End	½φ-5½	⅜φ-6	216	167				
				Interior	½φ-5½	⅜φ-5	269	210	166			
			End	Simple	½φ-4½	⅜φ-8	206	158				
				End	½φ-4½	⅜φ-8	217	167	129			
				Interior	½φ-4½	⅜φ-7	270	211	166	131		
			Interior	Simple	½φ-5½	⅜φ-8½	267	209				
				End	½φ-5½	⅜φ-8½	277	217	171			
				Interior	½φ-5½	⅜φ-8½	289	227	180	143		
6	75	0.500	Simple	Simple	½φ-5	⅜φ-7½	220	169	130			
				End	½φ-5	⅜φ-5½	277	216	170			
				Interior	½φ-5	⅜φ-4½		269	215	172		
			End	Simple	½φ-4	⅜φ-7	265	206	161			
				End	½φ-4	⅜φ-7	278	216	170	134		
				Interior	½φ-4	⅜φ-6½		271	216	173	139	
			Interior	Simple	½φ-5	⅜φ-7½		269	214			
				End	½φ-5	⅜φ-7½		278	221	178		
				Interior	½φ-5	⅜φ-7½		291	233	187	151	122
6½	81	0.542	Simple	Simple	⅝φ-7½	⅜φ-7	268	207	161	125		
				End	⅝φ-7½	½φ-9½		263	209	166		
				Interior	⅝φ-7½	½φ-7½			261	211	170	138
			End	Simple	⅝φ-6	⅜φ-6½		251	198	157		
				End	⅝φ-6	⅜φ-6½		263	209	166	132	
				Interior	⅝φ-6	⅜φ-6			263	212	171	139

7	88	0.583	Simple	Simple	5/8φ-6½	3/8φ-6½		257	202	159	124	
				End	5/8φ-6½	1/2φ-8½			257	206	165	133
				Interior	5/8φ-6½	1/2φ-7				260	212	173
			End	Simple	5/8φ-5½	3/8φ-6		308	244	195	156	
				End	5/8φ-5½	3/8φ-6			258	206	166	133
				Interior	5/8φ-5½	3/8φ-5½				261	213	174
			Interior	Simple	5/8φ-6½	3/8φ-6½				259	211	172
				End	5/8φ-6½	3/8φ-6½				269	219	180
				Interior	5/8φ-6½	3/8φ-6½				282	231	190
7½	94	0.625	Simple	Simple	5/8φ-6	3/8φ-6			246	195	155	123
				End	5/8φ-6	1/2φ-8				251	204	165
				Interior	5/8φ-6	1/2φ-6½					258	212
			End	Simple	5/8φ-5	3/8φ-5½			297	239	193	156
				End	5/8φ-5	3/8φ-5½				252	204	166
				Interior	5/8φ-5	1/2φ-9					260	214
			Interior	Simple	5/8φ-6	3/8φ-6					257	212
				End	5/8φ-6	3/8φ-6					267	220
				Interior	5/8φ-6	3/8φ-6					280	232
8	100	0.667	Simple	Simple	5/8φ-5½	1/2φ-10			295	226	190	153
				End	5/8φ-5½	1/2φ-7				301	246	202
				Interior	5/8φ-5½	1/2φ-6						257
			End	Simple	5/8φ-4½	1/2φ-9				287	234	191
				End	5/8φ-4½	1/2φ-9				302	247	202
				Interior	5/8φ-4½	1/2φ-8½						258
			Interior	Simple	5/8φ-5½	1/2φ-10						255
				End	5/8φ-5½	1/2φ-10						266
				Interior	5/8φ-5½	1/2φ-10						279
8½	106	0.708	Simple	Simple	3/4φ-8	1/2φ-9				274	222	180
				End	3/4φ-8	1/2φ-7					285	235
				Interior	3/4φ-8	1/2φ-5½						297
			End	Simple	3/4φ-6½	1/2φ-8½					271	223
				End	3/4φ-6½	1/2φ-8½					286	235
				Interior	3/4φ-6½	1/2φ-8						299
			Interior	Simple	3/4φ-8	1/2φ-9						295
				End	3/4φ-8	1/2φ-9						307
				Interior	3/4φ-8	1/2φ-9						323
9	113	0.750	Simple	Simple	3/4φ-7½	1/2φ-8½					261	212
				End	3/4φ-7½	1/2φ-6½						276
				Interior	3/4φ-7½	1/2φ-5						346
			End	Simple	3/4φ-6	1/2φ-8						262
				End	3/4φ-6	1/2φ-8						276
				Interior	3/4φ-6	1/2φ-7½						348
			Interior	Simple	3/4φ-7½	1/2φ-8½						344
				End	3/4φ-7½	1/2φ-8½						358
				Interior	3/4φ-7½	1/2φ-8½						375

1—r For Shear	
For Long Beam	For Short Beam
0.890	0.110
0.841	0.159
0.778	0.222
0.924	0.076
0.890	0.110
0.843	0.157
0.948	0.052
0.924	0.076
0.890	0.110

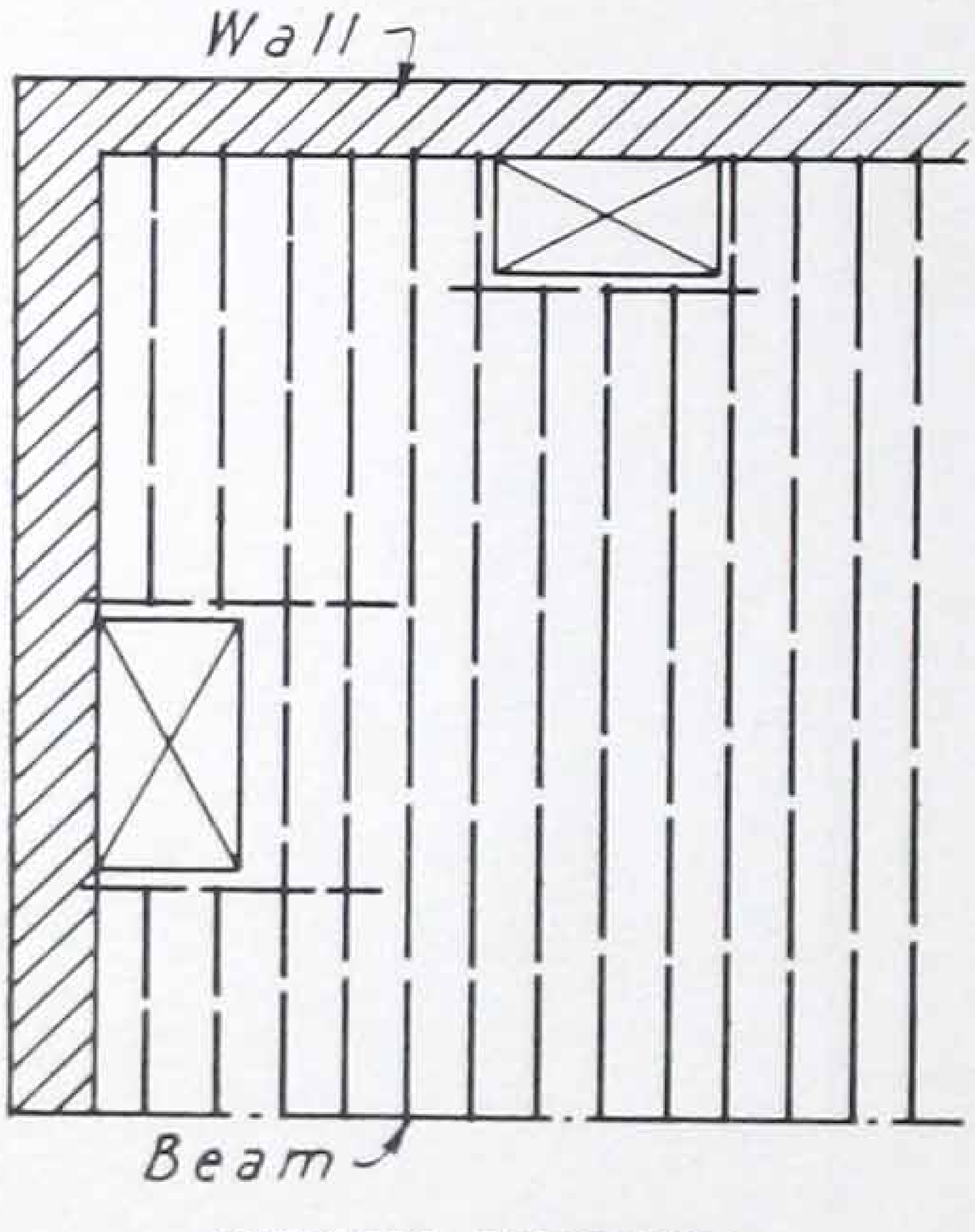
1—er For Bending	
For Long Beam	For Short Beam
0.936	0.111
0.905	0.255
0.865	0.370
0.957	0.077
0.936	0.111
0.907	0.250
0.971	0.052
0.957	0.078
0.936	0.111

SECTION IV—SPECIAL DETAILS OF CONSTRUCTION

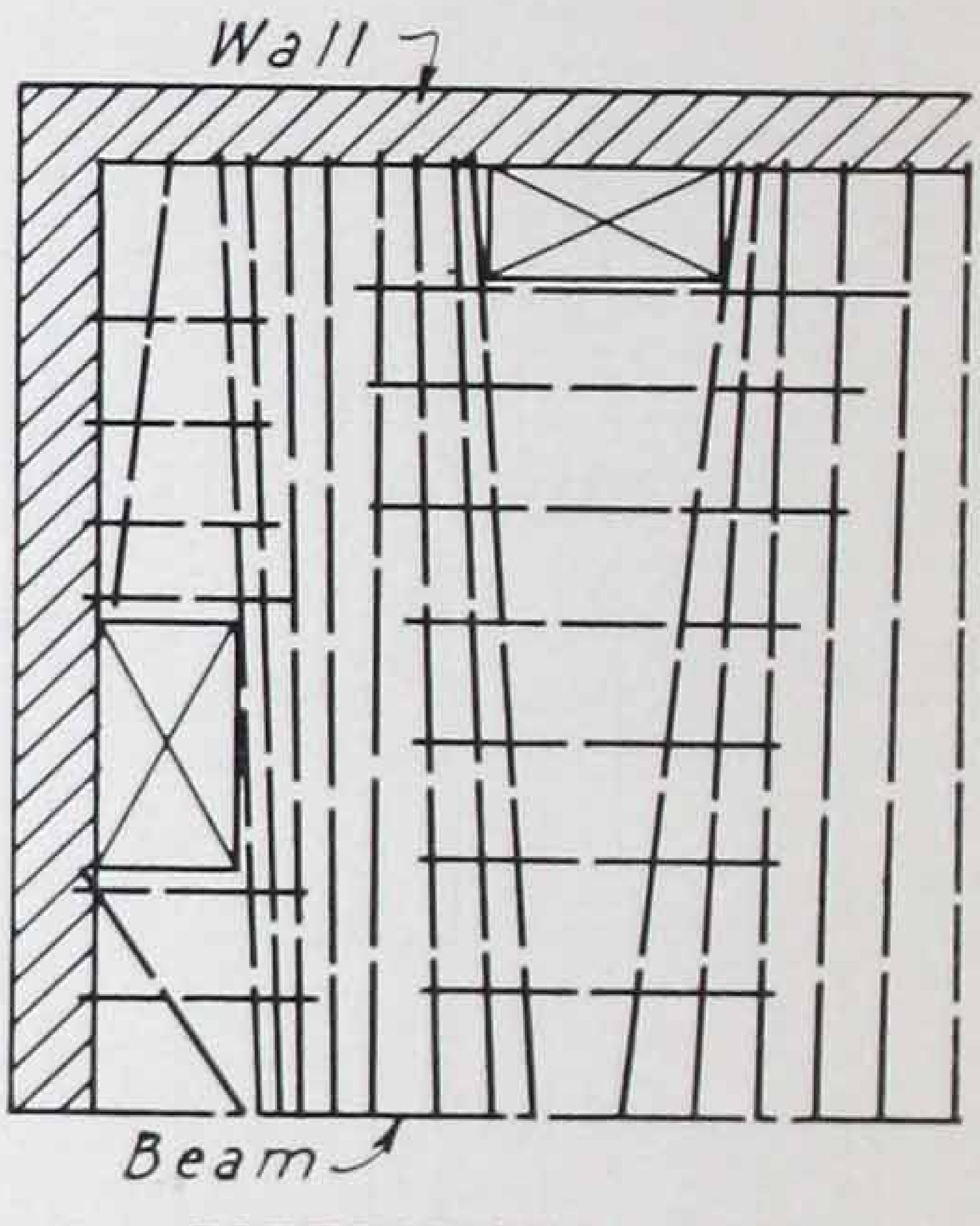
Openings in Slabs

Openings of various sizes and shapes will be encountered in any floor slab, due to stairs, elevator shafts, pipe shafts, and ventilating ducts. The method of providing for these depends largely on the ingenuity of the designer. Effort should always be made to preserve the continuity of the floor as far as possible and to eliminate framing beams or girders if it can be done without sacrificing stiffness and safety as a whole.

Small openings usually require merely a rearrangement of the reinforcing steel and the introduction of a few additional bars. A right and a wrong method are illustrated in Fig. 18.



WRONG METHOD



CORRECT METHOD

Fig. 18

Larger openings may sometimes be framed in one-way ribbed slabs by introducing header joists at right angles to the main joists and framing into wider or double joists along the sides of the opening.

Very large openings may be more economically framed by marginal beams, which in turn frame into the main supporting beams or girders.

Stairs and Stair Platforms

Reinforced concrete stairs usually consist of an inclined slab with the steps formed on its upper surface. These may be quite simply designed by reference to the following table.

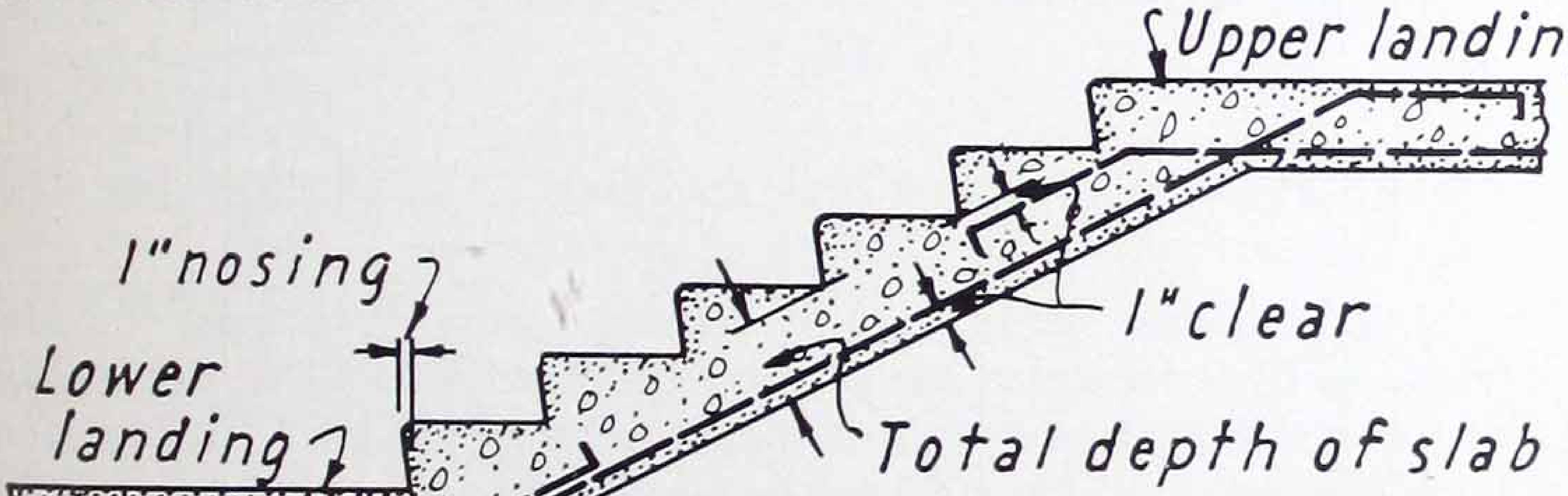
TABLE No. 23—TABLE OF CONCRETE STAIR SLABS

f_s = 20,000 p.s.i.
f_c = 800 p.s.i.
n = 15
$L.L$ = 100 p.s.f.

1″ Clear Protective Covering
Plastered Soffit

Horizontal Span of Stairs in Feet	Total Thickness of Slab in Inches	Reinforcing Steel
4	3	3/8″ϕ-7½″ o.c.
5	3½	3/8″ϕ-6½″ o.c.
6	4	3/8″ϕ-5½″ o.c.
7	4½	3/8″ϕ-4½″ o.c.
8	5	½″ϕ-7½″ o.c.
9	5½	½″ϕ-6½″ o.c.
10	6	½″ϕ-5½″ o.c.
11	6½	½″ϕ-5″ o.c.
12	7	5/8″ϕ-7″ o.c.
13	7½	5/8″ϕ-6½″ o.c.
14	8	5/8″ϕ-6″ o.c.
15	9	5/8″ϕ-5½″ o.c.
16	9½	¾″ϕ-7″ o.c.
17	10	¾″ϕ-6½″ o.c.
18	10½	¾″ϕ-6″ o.c.
19	11½	¾″ϕ-5½″ o.c.
20	12	¾″ϕ-5½″ o.c.

In stair flights which incorporate small platforms, care should be taken that the reinforcing steel is properly placed at the junction with the steps, particularly where the platform is at the top of the flight. Fig. 19 clearly shows this detail.



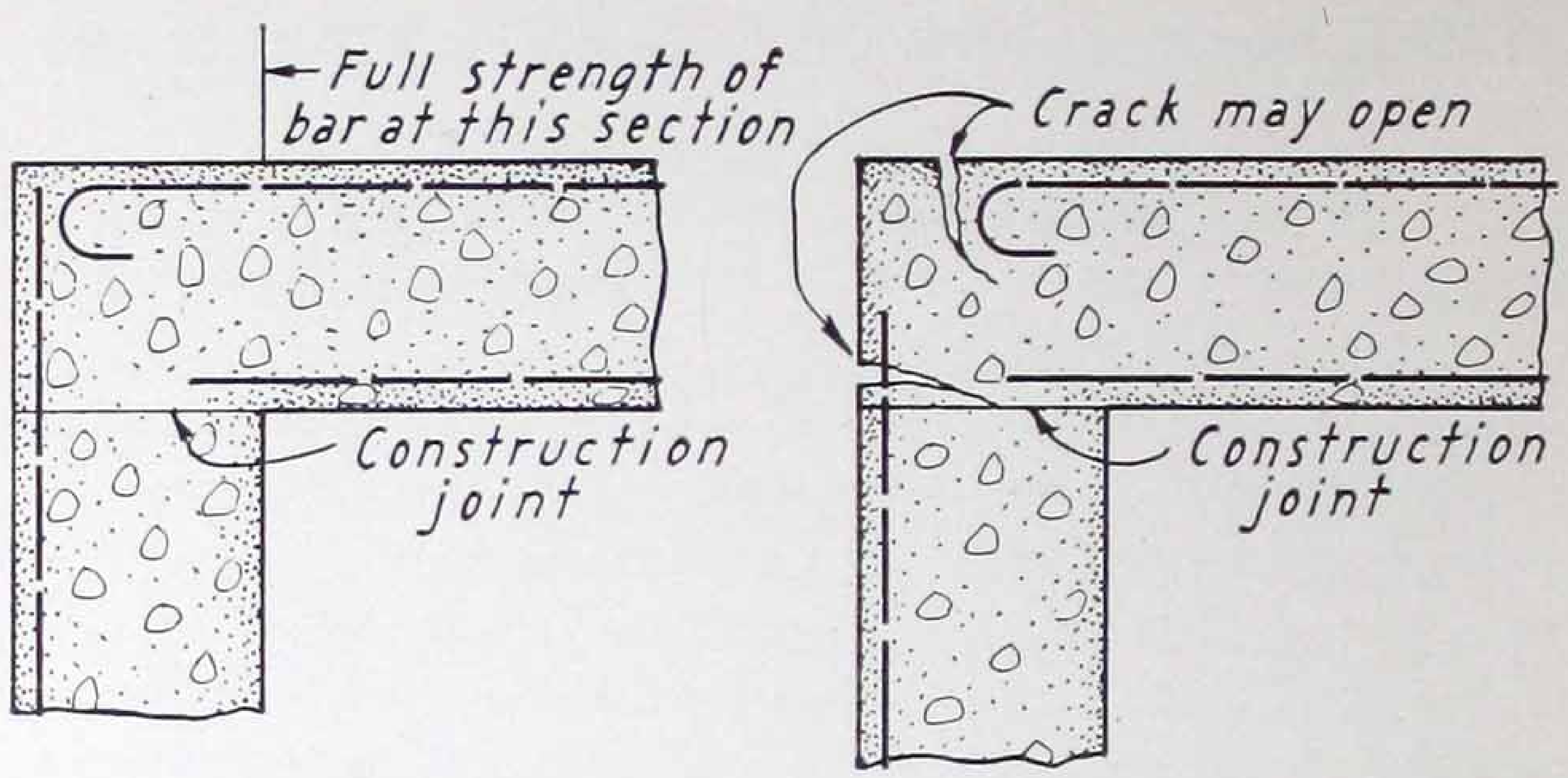
DETAIL OF STAIR AND LANDING

Fig. 19

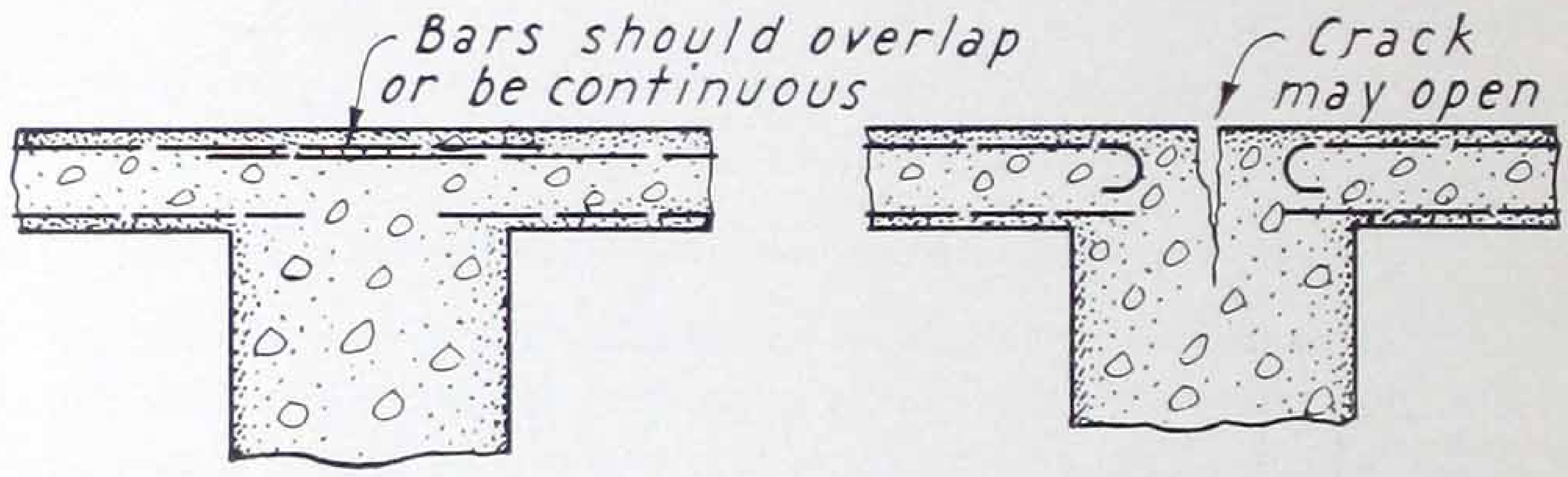
Methods of Anchoring Reinforcement in Discontinuous Slabs

There are several ways of anchoring bars at the edges of discontinuous slabs or beams. One is to extend the bar into the concrete of the support for such a distance that the stresses in the bar are gradually transferred by bond to the concrete of the support.

In cases where the support is not large enough to permit a bar to develop its bond, a hook should be provided at the end. Fig. 20 illustrates the right



CORRECT METHOD WRONG METHOD



CORRECT METHOD WRONG METHOD

Fig. 20

and wrong method of providing such anchorage. The effectiveness of a hook depends partly upon the strength of the concrete.

The ideal anchorage is obtained by a combination of straight embedment equal to 15 diameters of the bar and a semi-circular hook, the inside diameter of which is at least 4 times the diameter of the bar. With such a detail, the elastic limit of the steel can be reached without causing excessive stresses in the concrete.

Construction Joints

Construction joints will be necessary when the placing of concrete cannot be done continuously. They should be near the center of spans of beams and slabs, where the shear is a minimum. Bulkheads at right angles to the reinforcement prevent the last concrete placed from "feathering" out and provide a good surface for the further deposit of concrete. In ribbed slabs with metal pans, the bulkheads should be perpendicular to the joists. If they are set in the opposite direction, cracks sometimes develop at the joints.

TABLE No. 24—RECOMMENDED LIVE LOADS

	Lb. Per Sq. Ft.
Apartments	40
Armories	150
Auditoriums—fixed seats	50
Auditoriums—movable seats	100
Balconies and galleries—fixed seats	50
Balconies and galleries—movable seats	100
Dance halls	120
Dwellings	40
Exterior balconies	100
Fire escapes	100
Garages—all types of vehicles	100
Garages—passenger cars only	80
Gymnasiums	100
Hospitals—wards and rooms	40
Hospitals—corridors and public rooms	100
Hotels—guest rooms and corridors	40
Hotels—public rooms and public corridors	100
Libraries—reading rooms	50
Libraries—corridors	100
Loft buildings	100
Manufacturing—light	75
Manufacturing—heavy	125
Offices	50
Printing plants—composing and linotype rooms	100
Public rooms	100
Reviewing stands, bleachers, grandstands, etc.	100
Roof loads—rise less than 1 to 4	30
Schools—class rooms	50
Schools—corridors	100
Sidewalks—800 lb. concentrated or	250
Stairways	100
Storage—light	100
Storage—heavy, not less than	250
Stores—retail (light merchandise)	75
Stores—wholesale (light merchandise)	100
Theatres—stage floor	100

TABLE No. 25—WEIGHTS OF BUILDING MATERIALS

	Lb. Per Sq. Ft.
Asphalt (2″ thick)	25
Brickwork, common (per inch of thickness)	10
Cement floor finish (1″ thick)	12
Cinders (1″ thick)	3½
Composition roof	10
Concrete, cinder (1″ thick)	7
Concrete, stone or gravel (1″ thick)	12½
Continuous steel sash, glazed	8-10
Creosoted wood blocks (4″ thick)	20
Earth (12″ thick)	100
Gypsum (1″ thick)	3
Hollow clay tile (3″ thick)	15
Hollow clay tile (4″ thick)	16
Hollow clay tile (6″ thick)	22
Hollow clay tile (8″ thick)	30
Hollow clay tile (10″ thick)	36
Hollow clay tile (12″ thick)	40
Lightweight Concrete Tile—5″ x 4″ x 12″	14
Lightweight Concrete Tile—5″ x 6″ x 12″	22
Lightweight Concrete Tile—5″ x 8″ x 12″	28
Limestone masonry (12″ thick)	160
Marble masonry (12″ thick)	170
Partitions, 2 x 4 stud, plastered both sides	16
Partitions, solid plaster (2″ thick)	20
Plaster, on tile or concrete	5
Plaster, on metal lath	10
Polished plate glass	3½
Pressed steel ceilings	2
Quarry tile (1″ thick)	12
Sand (1″ thick)	9
Sheathing, Y.P. (1″ thick)	4
Sidewalk lights	40
Skylights, metal, with wire glass	6
Slate roof	6
Steel sash, glazed with S.S. glass	5
Terrazzo floor (2″ thick)	25

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